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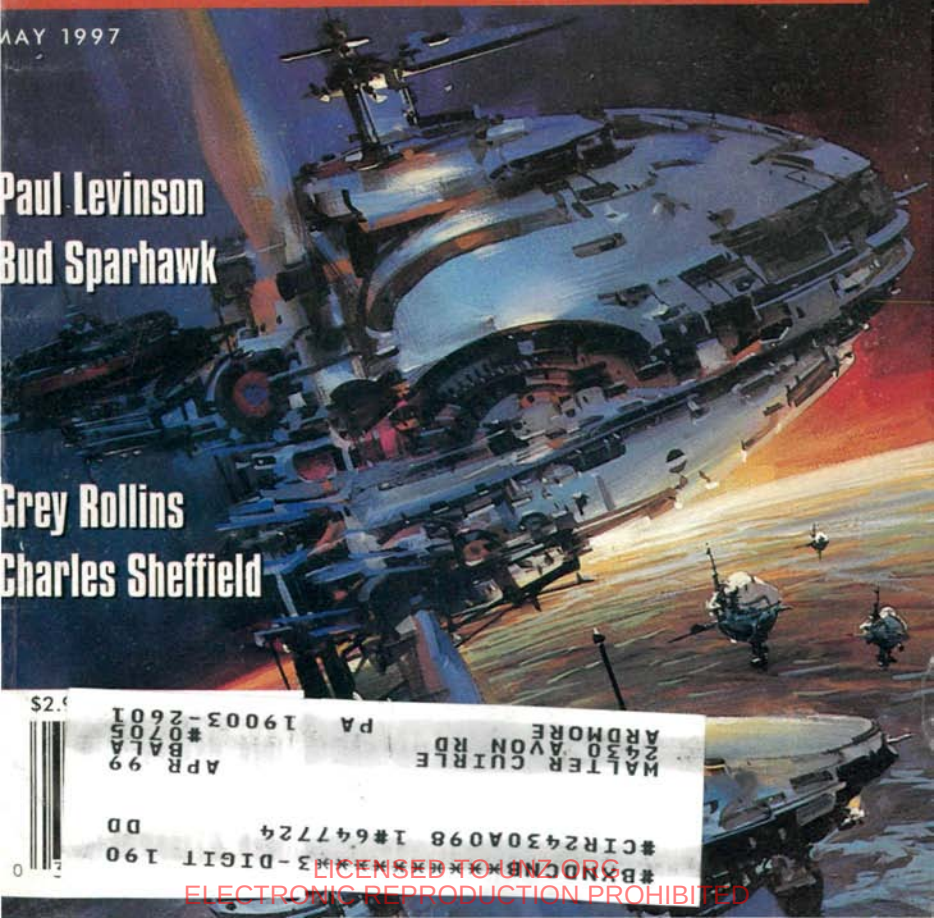

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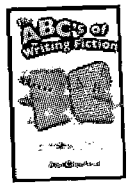

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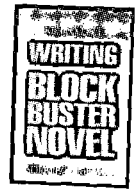

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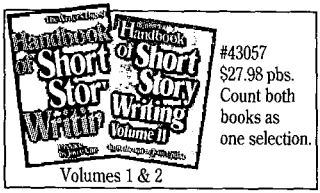

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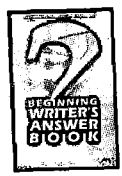

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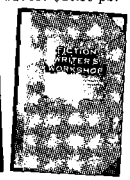

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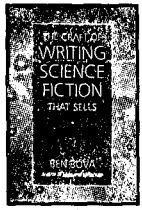

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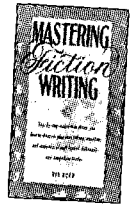

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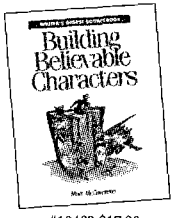

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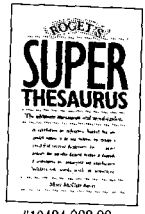

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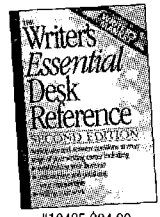

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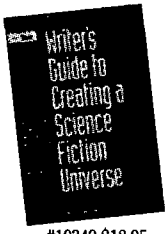

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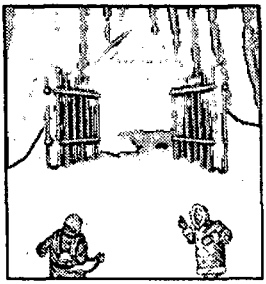

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SCIENCE FICTION AND FACT

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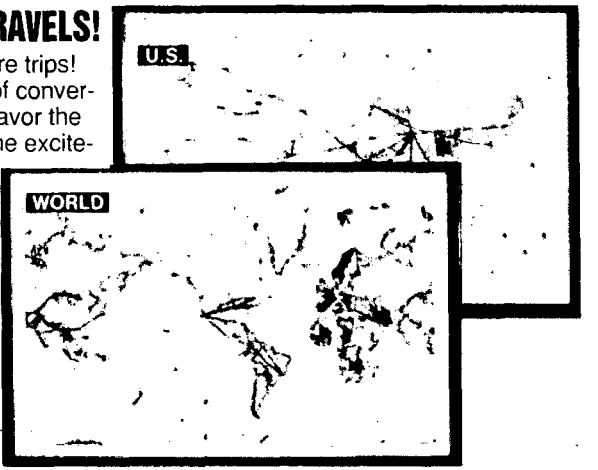

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A BAD TIME FOR ALIENS

If you were an extraterrestrial, planning your first visit to Earth, would this be a good time to come?

Would it really *matter* when aliens decided to make their first appearance here[1]? That is, would some historical periods be more conducive than others to a smooth "breaking of ice"? Quite possibly so, if only because how the locals (that's us) respond to the newcomers will inevitably depend on their mindset at the time of first contact. That, in turn, will depend on what they've been doing and thinking.

For much of recent history, few humans did much thinking about the possibility of contact with nonhuman and/or extraterrestrial intelligences, and those who did were generally regarded as oddballs. "In the beginning," by which I mean such things as the early science fiction of H. G. Wells and the pulp magazines of the 1930s, alien visitors to Earth had a strong tendency to be hostile and fearsome monsters. The Martians in *The War of the Worlds* at least had a more or less plausible reason for invading Earth: They needed new real estate because their own had deteriorated. Many other motives were flimsier, even unto aliens wanting humans for food or breeding partners.

The common denominator was that most aliens were things to be fought off, defended against, and, if possible, exterminated. Few writers made much attempt to get inside their minds and imagine what might really make them tick—and perhaps even invite human sympathy. Alien monsters became such a cliché that "BEM," an acronym for "bug-eyed monster," was often used almost synonymously with "alien."

That gradually began to change. A widely recognized landmark was Stanley G. Weinbaum's novelette "A Martian Odyssey," featuring an alien *not* bent on destruction for its own sake and at least somewhat understandable as a sympathetic character with aims and motivations growing logically out of its own distinctly nonhuman nature. The trend toward sympathetic aliens grew in some circles, especially in this magazine. When John W. Campbell, Jr., was editor, he repeated-

[1] I'm assuming, for the sake of argument, that they haven't already done so, since, at the very least, they haven't made any appearances that are general public knowledge (or my personal knowledge).

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ly challenged its writers to "Show me something that thinks as well as a man, but not *like* a man!"

Those magazines, though, were still read by quite a small percentage of the population. More popular were "science fiction" movies containing precious little science but lots of fiction in the well-worn vein of "invaders from outer space." To the extent that most people thought about aliens at all, they were *a priori* something to be feared and fought. It would not have been, I suspect, a good time for alien visitors to arrive.

More recently, though, there seemed to be a widespread shift toward sympathetic aliens even in the popular media. *Star Trek*, surprisingly and admirably, included *both* sympathetic and hostile aliens, which seems likely to approximate what we might eventually find if there really are lots of species out there. In the '80s sympathetic aliens actually seemed to predominate, from the immensely popular movie *E.T.* to such silly but amiable television series as *Mork and Mindy* and *Alf*.

Some of us began to suspect that maybe large numbers of people were finally being made to feel comfortable enough with the concept that it might not be such a bad time for friendly aliens to knock at our door. On the other hand, the thought also crossed my mind that maybe we had gone from one extreme to another: from all-aliens-are-monsters to all-aliens-are-cute-and-cuddly-and-friendly, which could be a risky thing to assume. I put in my own two cents' worth in *Tweedlioop*, which, among other things, suggested that peoples' reactions to cute-and-cuddliness could actually make life easier for some threatening aliens.

Now we seem to be in a new period when most of the aliens depicted in movies and television are destructive monsters reminiscent of 1930s' BEMs, but with bigger and better special effects. Obvious examples include last summer's box-office blockbuster *Independence Day* and its television look-alike *Dark Skies*.

If this is indeed a new trend, I can't help speculating on a connection with another observation I made a few years ago. When the Iron Curtain fell apart, beginning in 1989, we heard a lot of talk about "needing" a new enemy. That led me to write "Beyond Them and Us" (*Analog*, Mid-December 1992), naively musing that maybe the occasion should suggest

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not the need for a new enemy, but an unprecedented opportunity to outgrow the psychological habit of thinking that way.

Mine was a minority view, of course, and I suppose some folks will be delighted to hear that it looks as if a lot of people have now found that new enemy they were seeking. If we can't depict anybody on Earth as Bad Guys, the popular sentiment seems to go, let's show aliens that way! We may not have any *real* aliens to pick on, so far, but vividly imagined ones may be the next best thing while we're waiting....

I realize that possible aliens may well include some at both extremes of any spectrum (and probably many more *between* the extremes). But what I seem to be seeing is a trend in which a disproportionate number of extraterrestrials are cast in the Monstrously Threatening role.

And that could make this a very bad time for real aliens to arrive—for us as well as them.

How we react to people we meet (and I'm using "people" here in the broadest possible sense) is often shaped at least as much by our preconceived expectations as by their actual character. I remember dreading starting one year of grade school because of the horror stories I'd heard from other students about my teacher-to-be. Some of my classmates, once the class was underway, agreed that the horror stories were well-founded. I did not—perhaps because my parents knew of my concerns and cautioned me that I should give her a chance and make up my own mind because the stories might not be true. I tried to do that, and found that I actually liked the teacher in question. Then again, maybe we

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TECHNOLOGY UPDATE

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■ *The Phazer will "jam" both radar and laser guns, preventing police from measuring your speed.*

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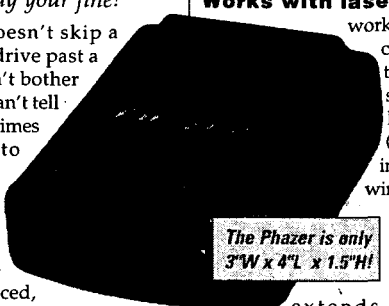

■ Radar with FM "chirp"
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were *all* influenced by what we were led to expect.

Similar considerations, I suspect, apply to the ways humans might react to an alien visitation. If we haven't been thinking about their possibility at all, we would probably greet them with the knee-jerk fear and defensiveness most people have toward the unknown. In a period when it's been fashionable to imagine them as new friends or saviors, with little thought for other possibilities, we might offer them a warm reception—whether they deserve it or not. At a time like now, when fashion calls for making aliens almost automatically the Bad Guys, too many of us might shoot first and ask questions later.

Clearly, the only *rational* course is to try to imagine and be prepared for the entire range of possibilities, while resisting the temptation to assume that any particular *real* aliens will closely resemble *any* of our imaginings. That is, of course, what responsible science fiction, taken as a whole, has always tried to do.

But how often has the general populace been rational and responsible? Until such time, if any, as that happens, I'd advise any aliens contemplating a visit to Earth to be well aware of our propensity for fads, and wait for a time when tolerance and open-mindedness are in vogue. Such times are regrettably rare, but I strongly suspect they can do better than now. ■

It's a vice to trust all, and equally a vice to trust none.

—Seneca

The best thing about the future is that it comes only one day at a time.

—Abraham Lincoln

Everything has been thought of before, but the problem is to think of it again.

—Johann W. von Goethe

TWO OBSERVATIONS ON EARTH'S CONVERSION TO AN OXIDIZING ATMOSPHERE

We don't see it as the biggest ecological catastrophe in history because the winners write the history books.

—Common Knowledge

And the losers become internal parasites.

—Karen Anderson's Corollary

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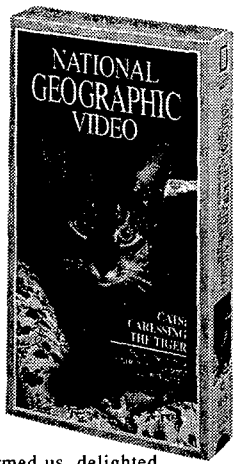

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Paul Levinson

LOOSE ENDS

It can be hard to judge how you're doing on a very big problem. . . .

Illustrated by Darryl Elliott

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Jeff felt a certain hardness under his backside, as if he had fallen asleep on a plush chair and come awake on a park bench somewhere.

He opened his eyes and stared at his destiny: a large and messy lounge of some sort, outlines indistinct in what must have been the reflected light of evening street lamps. There was no doubt about it. The broken-down couch in the corner, worn wooden study tables to the right, books and papers and misshapen armchairs strewn around like some old rummage sale—this was a far cry indeed from the cool flowing continuum of the control room. The Thorne had worked after all.

Jeff strained to keep his adrenaline in check. Not even a cleaning person in the unlit room. Good. It was late at night, maybe even a weekend. No one to bump into. He pulled a low-intensity fireflighter from his pocket. In the weak approximation of daylight, the lounge looked even more 20th century. Remarkable! On the floor near his feet, he noticed a ratty-looking issue of *Look* magazine. The August 23, 1963 date on the cover caused another rush in his veins, but told him not enough of what he needed to know. The magazine could have been lying around for years by the looks of this room.

He had to know the exact date of his arrival. It would tell him which of the eight plans to implement. Clutching his deliberately nondescript suitcase, he walked quickly to the door. He noticed a torn *Time* magazine dated October-something, 1963, and frowned.

Jeff delicately opened the door and patted the shirt of his janitor's outfit. He was an academic with strong ties to the working class—his great-great-grandparents had slaved in sweatshops—and he welcomed the prospect of testing out his jargon, costume, and identity on the local populace. Unfortunately—or fortunately—no victims were in sight. He walked out, carefully closed the door behind, and strode in search of an exit.

"Sher-er-ry, Sherry baby. She-er-ry. . ."

For some moments now, Jeff thought he had been hearing a faint falsetto whining. He walked down the last flight of stairs, out into the street, and recognized the shrieks as "Sherry"—an early rock hit by the Four Seasons. More inconclusive evidence, not particularly heartening. He'd done a special lecture on the Seasons and the Beach Boys just last year, and knew for a fact this song came from the summer of 1962.

The air felt chilled, like maybe early October. A '59 or '60 Fairlane 500, from which the Seasons' song seemed to be emanating, was no more help in establishing an exact date than the song.

The street beyond the Fairlane looked clearer and uglier than he'd expected—a bright messy watercolor spilling onto itself. He wondered what his expectations about this place were really based on. Probably more on Andrews's "Village Squared" hit of last year than the hours of 1980s film and photographs he had reviewed till his eyes had burned with fatigue.

He spotted a blonde girl in what used to be called dungarees walking

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towards him. "Uh, pardon me, Miss," he said as nonchalantly as he could, "do you know the time . . . and the date please?"

She gave him a strange look and glanced at her watch. "A quarter to twelve," she said, without slowing a step.

Well, thanks a lot, Jeff thought. "Excuse me, Miss, I'm sorry to bother you, but if you could tell me the date as well. . . ." He found himself shouting after her. She just kept walking. He shook his head and walked the other way.

The chill was beginning to eat at him as he made his way towards West Fourth Street and Washington Square Park. There the usual complement of derelicts and weirdos—some things never change, he smiled—were keeping the late-night vigil. No point in trying to get a straight answer about the date from that crew. He sighed, then noticed the quaint old phone booth on the corner. He picked up the receiver and pumped in eight quarters in rapid sequence to make sure he would get a connection. "Hello, Operator, could you tell me what today's date is?"

"The date, sir? I'm sorry, but we're only supposed to give out numbers."

"Well, is there a number I can call to find out the date?" A faint odor of urine permeated the booth.

"Checking, sir. No, I have a number for the time, but I don't see one for the date."

"Well, then, do you think you could be a human being instead of, uh, a computer, and tell me the date anyway?"

"I'm sorry, sir, but we're only supposed to give out numbers."

"And have you no function in the universe or reason for existence other than giving out numbers?"

"I have no function, sir."

Jeff slammed the phone down and shook his head. I'd make a great diplomat, he thought. At this rate, I—

"Having trouble with the phone, Jack?" Jeff turned to find himself addressed by—was it a slacker or a hippie?—about twenty-five years of age. "The phone company's been hangin' *every*one up lately, man."

"Yeah," Jeff smiled, "it's getting worse and worse. Look, I wonder if you might be able to help me. I'm disoriented, I've got to know what the date is." Jeff leaned out of the booth, deaf to the quarters that clanged in the coin return.

"I can dig it, man, really."

"Good, then, can you tell me what the date is?" He inhaled deeply of the less tainted air outside the booth. Compared to what he had just been breathing in, it smelled like perfume.

"Well, like, that's a difficult question, man. I mean it's November 21st now, but it'll be November 22nd in a few minutes. And of course for the cats over in England it's already been November 22nd for a few hours, and—"

"OK, good," Jeff said. "And the year?"

"The year?"

"Right, the year—as in 19. . . ."

"Oh, well that's the same everywhere, man. 1963."

"What?"

"I know it, man, time flies faster

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and faster these days. . . ."

Jeff walked dazedly down the street, fighting to think through flashes that spat at his brain. What the hell was this? He was supposed to have emerged some time in the fall—the end of November was cutting it a little close, but OK, that still gave him at least some weeks to get to NASA, Morton Thiokol, whomever. He knew the Thorne wasn't perfectly precise. How could it be—generating the kind of savagely powerful local field needed to keep the Artificial Worm Hole open long enough to operate across time. So it couldn't be that exact. But twenty-three years? What could he do to prevent the *Challenger* explosion back here in 1963?

He shook his head and it cleared a little. He had no choice now but to return to the lounge, activate the mechanism for return to 2084, and try the damn thing again. He retraced his steps to the Student Building. But his legs moved slower and slower, as if they opposed the decision to return. Finally he stopped.

He stared at the Student Building across the street. He focused on its gargoyled facade and played with a quarter in his pocket. He pivoted suddenly and walked quickly again in the direction of the park. A hundred and twenty-one years was a long time to have traveled into the past just to rush right back. He could take a few more minutes to think this over.

He wandered towards Sixth Avenue, then inside a coffee shop. He sat down and read the sticky plastic menu without comprehension. The cracks in the red leatherette upholstery jabbed his thighs.

"Had a rough day, huh, honey? What'll it be?" The dyed blonde waitress was right out of a turn-of-the-cen video. Upset as he was, Jeff the cultural historian liked this.

"Just a tea with milk, please." By any conceivable logic, he ought to return as soon as possible to 2084, so he could try this again, and with any luck arrive at least a few months before January 28, 1986. To do that, he had to go back now to the lounge in the NYU Student Building from which he'd emerged, the exact same place, that was the way the Thorne worked.

But something in Jeff rebelled against this logic—something in his nature which said, look, you've gotten this far, it's not good, but you may never get this far again, so you better take what you can of this chance to save the space program. . . .

But how?

He'd have to improvise.

He thought about the endless careful plans his team had made for him to avoid getting caught up in some paradox—keep the loop clean, don't do anything in the past that might undermine the very foundation of this project. Steer clear of everyone's great-grandparents. . . . Jeez, how the hell was he supposed to do that back here, twenty-three years earlier than he'd planned to arrive, when he had no idea where everyone he was supposed to avoid was?

Jeff rubbed under his head. Every second that he stayed here was a knife at the throat of his future. He was off the screen, way out of equation-

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range—a single word to a wrong person, some land-mine of the past, could set in motion a chain of events that erased his colleagues, maybe even him, from existence. True, he had no close family, no one that he really loved deeply anymore—well, maybe still Rena, in a way—but he certainly hadn't undertaken this job to kill his friends, make himself a martyr to a reconstituted future that might never know he'd existed in the first place.

On the other hand, how likely was it that he'd run into such a land-mine? Painstaking tests had shown that the effects of most interjections in the past were sooner or later washed out in the myriad of everything else that remained the same. And how could anyone from his vantage point truly know what was intended all along? Maybe he'd always been supposed to arrive here back in 1963—maybe he was ordained to help the space program, or humanity, in some way other than stopping the *Challenger*. Maybe that's why the *Challenger* blew up after all, because there was no way he could influence events this far back to stop the explosion that took the heart and soul out of the space program, had set up the 21st century to be little more than an age of commentary looking back on the Golden Age. His head spun. He could feel the sweet buzzing vortex of paradox whispering in his brain, drawing him in. . . . No, I have free will, I'll do what I damn well choose, I don't have time for paradox now, I only have time to act.

He looked at the clock on the wall. Twelve minutes after twelve. Too much lead time for the *Challenger*—the shuttle had barely been conceived of in 1963. He supposed he could live the next twenty-three years in normal time here, and devise a new plan to thwart the explosion. Thiokol Chemical Corporation had been awarded the NASA contract to build the shuttle's solid rocket boosters on November 20, 1973—just about ten years from where he was now—so if he could hang on for a decade, he might even be able to begin doing some good then. Leroy Day had been picked to head planning for the shuttle in 1969, a few years nearer.

But this didn't seem appealing. Ten years, even five, was a long time to stay out of trouble. And he couldn't even be sure that the Artificial Worm Hole would remain operational that long. The most their tests had confirmed was safe return after eighteen months in the past.

He, of course, knew exactly what else he might try to do on this date. He knew its obvious significance. He didn't have to be a cultural historian by training to know it. Jeez, he'd arrived at the edge of the oldest cliché in the science fiction CD. Everyone and their great-aunt Martha had written a story about it.

What was the likelihood that some error in the team's calculations, some unexpected flux in the AWH, had landed him here on this of all dates? Maybe it wasn't an accident that he'd somehow been dropped at the doorstep of what *Time,* nearly a century in his past and thirty-seven years from now, had dubbed one of the top five murders of the millennium.

But if so, what was its deeper purpose?

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Surely not to stop the events in Dallas tomorrow—there really wasn't enough time. He was in New York City, after midnight, on November 22, 1963. Way too soon for *Challenger*. All but too late for JFK.

All but too late . . . But what else could he could do back here, then? What else had he perhaps been *meant* to do here?

He shook his head.

Did they even have air service to Dallas this late at night? He didn't know. What kinds of planes? Propellers? No, probably jets already.

Dallas was a thriving city even back in the 1960s, and at the very least he would probably be able to get a businessman's flight early in the morning. But would that leave him enough hours? What was the point of flying all the way to Dallas just in time to hear that JFK had been shot?

But what was his alternative if he didn't use the AWH to return to his starting point? Sit around like a jackass and wait for Walter Cronkite's tear-choked voice to announce the assassination on TV?

Blondie arrived with his tea. Fortunately it was lukewarm, and Jeff was able to drink it down in two gulps. He pulled a crumpled bill out of his wallet and left it on the table. Some bank clerk in the next few weeks would be stunned to see a 1981-issue ten-dollar bill with Donald T. Regan's signature, but he had no other money, and had to take a chance that such a minor anonymous anachronism wouldn't disturb the time-line. Loops could be perfectly clean only in theory. The bill would likely be dismissed as a clumsy counterfeit or a joke. Maybe it would be lost before it even got to a bank teller.

He walked out onto Sixth Avenue and surveyed his options yet one more time. The city was harsh, the air stank, he didn't belong here. The sensible thing to do was return to 2084. And yet . . .

He flagged down a passing cab. "Kennedy, uh . . . Idlewild Airport. On the double, Chief." As the cab pulled away, Jeff recalled George Bernard Shaw's line that the reasonable man adapts to his surroundings, the unreasonable man attempts to change his surroundings to suit himself, and all progress depends upon the unreasonable man.

There had to be something more to this than Dallas, but at this point Dallas seemed the only way to get to it.

Inside the coffee shop, the waitress stuffed the bill in her bosom pocket and laughed. "I tell ya," she said to the fat man stuck behind the cash register like a melon, "these actor types are all the same. They never remember to wait for their change. I'm gonna keep this for good luck."

"Tunnel or Bridge?" the cabbie grunted through chewing gum.

Jeff wasn't completely sure what he was talking about. "Do what you think best, Mac. Just get me to the airport as fast as you can." He shifted his weight on the springy seat and looked through the dirt-caked window. . . .

"Just got off the late shift, right? My brother-in-law does the midnight-to-eight shift for Helmsley. You gotta do what you gotta do to make a living

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these days, right? What's the use of talking."

"Yeah, the inflation's impossible," Jeff agreed. Can't go wrong in any century griping about inflation. And he made a note to himself to get out of the janitor's outfit as soon as he got to the airport.

"Yeah," the cabbie growled, "ain't it the truth."

Jeff felt in his pocket for his reassuring puterwafer but got no comfort from it. He was fully on his own now, plans pertaining to twenty-three years in the future all but worthless. In a worst-case scenario, if all he could catch was an early-morning flight, he'd have maybe an hour or two to get to the Book Depository Building in Dealey Plaza after his plane arrived in Dallas. If he could somehow get to the Building by eleven, he'd stake out the upper floors and try to intercept the gunman . . . or gunmen . . . or gunwomen. He wondered whether he'd find Lee Harvey Oswald up there by those windows. Historians would give their right arms to know. A hundred and twenty years of theorizing had left them no closer to knowing who had killed Kennedy than the unsatisfying "lone nut" explanation of the Warren Commission.

One thing Jeff did know: the assassination of JFK probably did more to ultimately harm the prospects of humans in space than even the horrible *Challenger* disaster. His team had briefly considered sending him back here to 1963 in the first place, but rejected it on the grounds that too much was still unknown about the assassination for them to mount an effective plan to stop it. So here Jeff was without a plan anyway . . . rushing like a moth to a flame that he had little chance of extinguishing, but which was too attractive to resist. . . .

"Any special terminal, Mac?" The grunt drew Jeff back to the real world, though this ride seemed scarcely more real than his musings. He looked at his watch and whistled. This old gasser had gotten him to the airport in under an hour. "American Airlines, Chief, and thanks." Jeff set his watch to the time on the foolish-looking clock pasted on the cabbie's dashboard. It was now 1:07 in the morning of November 22.

He paid in dirty dollar bills printed twenty years in the future and sprinted into the terminal—a garish but not uncharming combination of wine-red carpet and shiny chrome trimming. It reminded Jeff of early Technicolor movies. He ducked into the men's room, unpacked clothes from his suitcase, and shortly emerged a stylish '80s businessman. He expected this wouldn't cause too much of a problem—if his clothes looked a little odd, people would likely chalk that up to his dressing European. There was more difference in hemispheric styles in this century.

He approached what appeared to be a mock-wood ticket desk. The pert red-headed Kewpie-doll behind the counter added to his feeling that he was in an ancient film. "Am I in time for the late-night flight to Dallas?" he asked with his friendliest smile.

"Oh, I'm very sorry, sir, but our last connecting flight left at 12:30. Our next one leaves at 10:00 this morning,

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and I believe that Braniff has a direct flight that leaves at 9:00. Shall I make a reservation for you?"

Damn. "Could you tell me what time the Braniff flight arrives in Dallas?"

She pulled out a paper directory and checked. "Eleven thirty-three Dallas time, sir. Shall I make the reservation?"

"Yes, please do," Jeff said, "and could you point me in the direction of the airport hotel?" Jeff paid in cash—he had a bunch of credit cards too, but they were all hopelessly out of date, in the wrong way. She counted the money and Jeff held his breath. The bills were small denomination, suitably soiled, from the 1970s. She didn't notice anything askew.

Jeff walked slowly to the end of the terminal. It would be ridiculously close in Dallas—even if the plane landed on time, he'd have just an hour to get to the Book Depository and stop the killing.

The bed in the International was unexpectedly comfortable though the room, like the airport terminal, had some faintly artificial smell. Jeff fell soundly asleep, and dreamed he was in a classroom giving his "Earth Was Never Room Enough" talk while Dion's "Abraham, Martin, and John" played in the background. Rena sat in the front with her legs seductively crossed, but her face looked a lot like Sandra Dee's. He could hear someone talking just outside the classroom, going on and on and utterly ignoring his lecture. It was James C. Fletcher, NASA administrator who had had the most to do with the shuttle program. Jeff was screaming at his students to pay attention when the phone rang.

He fumbled with the ungainly receiver and dropped it. Then he smacked himself in the mouth with it. "Hello," he finally managed, rubbing his eyes and looking in vain for the viewer.

"Good morning, Dr. Harris! Five thirty wake-up call!" a sing-song female voice chimed merrily.

"Thanks." Jeff replaced the receiver with great effort and sat up. He rubbed his sore lips and fought off the impulse to go back to sleep for just another fifteen minutes. He could sleep for fifteen days, the way he felt, but he dragged his body out of bed and quickly dressed. Last night's businessman with maybe a blue knit tie to go with the gray wool suit would do fine.

The coffee house was a zoo. He hadn't much appetite, but forced himself to eat the soggy eggs for strength. Looking around, he realized again that there was a lot he didn't like about this place. Historians like their history from the safety and convenience of the future—the past on a platter with all the comforts of home. Not like this. . . .

"Excuse me, sir." The waitress startled Jeff as she leaned over with the check. "That's an interesting bracelet you've got on there. My husband's a jeweler, and I don't think I've ever seen anything like it."

"Uh, thank you." Jeff glanced down at his watch, scooped up the check, and quickly left the table. "My, uh, kid's studying electronics," he said half over his shoulder, "and it's something he designed for me." Great. He'd been wearing this flector for six

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years now, and with all the departure commotion yesterday he'd forgotten to take it off. Hustling to Braniff Departures, he removed the silver sliver from its embed on his wrist and placed it in a side compartment of his suitcase. Then he took out the clunky Timex analog someone had given him, and stopped a moment to set it and strap it on his wrist. He shook his head in self-disgust. First the future bills he was handing out like candy, and now this. The money he had no choice about, but the flector was sheer stupidity on his part.

He sighed. It didn't really matter. If by some wild luck he could stop the JFK assassination in Dallas, nothing that he did now would make much difference. If not, well . . .

The plane was a sardine can, and Jeff sat white-knuckled in a window seat waiting for takeoff. Finally it began making taxiing noises, the comforting rumblings of some great beast's innards, and Jeff leaned back and tried to relax. The stewardess had a tight skirt on, pitching her derriere right at him, better view than the window.

Well, so far his rating of 1963 was food and decor not too good, women a distinct possibility. This seemed in line with that refrain from the classic Woody Guthrie song about the social fallout of relativity: Can't go North, can't go South, or up, down, anymore. But I can still go in and out, Mr. Einstein, I can still go in and out. . . .

It remained to be seen whether he could get in and out of the Book Depository in time.

The 707 pierced like a needle through the remnants of haze over Dallas. Jeff peered through his peephole at the airport below as the captain announced they'd be landing momentarily.

He had so little time. Everything depended on his getting to the Book Depository as quickly as possible. He'd shove through lines, jump over turnstiles, knock people down if he had to. No gesture of asinine civility could be allowed to slow his exit.

The screech of the aircraft hitting the ground hiked his pulse. He felt the seconds ticking, each in phase with his pounding blood. He braced for the performance. He could see nothing but the taxi at the end of the tunnel, the taxi that would bring him face-to-face with God-knew-what at the Book Depository.

The plane shuddered still. Its doors grumbled open. Debarking passengers spilled like mindless ooze into the terminal. But one of their number was more minded than he'd ever been in his life: single-minded in his determination to dive into that cab. Get out of my way, you goddamn fools. I don't have time to say sorry.

Jeff swam in powerful strokes through the current, halfway through the terminal, now three-quarters through and almost out. Every shred of his being, every ounce of his purpose, was focused on closing this last little gap to the exit. He was almost believing that maybe he would stop the assassination after all, maybe this was the way indeed that he was destined to save the space program. He saw JFK's face before him, superimposed on the *Challenger,* superim-

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posed on the flames, superimposed on innumerable stars. . . .

Which was why he never saw the towering cart of luggage that fell upon him less than three feet from the glass doors, and knocked him unconscious.

He opened his eyes to a throbbing headache and blurry white of what must have been a hospital room. Fumes of formaldehyde hung in his nostrils and made him gag. "I see you're awake, Dr. Harris," a lazy Texas accent jarred him. "You ran into a rack of luggage at the airport and sustained a moderate concussion, but you're going to be just fine."

Jeff leaned up on an elbow to get a look at the nurse. "Where am I?"

"St. Paul Hospital. We'll need to run a few tests on you, and if everything's all right you'll probably be able to leave in the morning."

"I . . ." Jeff fell back on the pillow and tried to breathe slowly. He felt cold and clammy and slightly in shock. He took several deep breaths, and tried to focus more clearly on the nurse. Her eyes looked red and puffy. Outside his room he heard what sounded like a radio or holocenter blaring in the corridor—a tumult of loud talking and wailing. "What's going on out there?"

Nurse K. Arthur burst into tears, and Jeff got a sudden feeling in the pit of his stomach that he knew exactly what the ruckus was about.

"They killed the President," she sobbed. "I really shouldn't disturb you with this. They rushed him to Parkland Memorial, but he was too far gone." She heaved with tears. "He was so young, so beautiful. Why would anyone want to *do* something like that?"

Jeff reached out to comfort her. "Ow!" Pain cut through his back like a stiletto.

"Here, let me help you." Arthur leaned over and gently eased Jeff back into bed. "You probably wrenched a muscle or two." She puffed up the pillow and smiled. "There. I'll tell the doctor you're up and I'm sure he'll look in on you a little later." Her smile suddenly wavered and tears welled up again in her eyes. "They wounded Vice President Johnson and killed Governor Connally. They say it was one of those Communists. What's going to happen to the country now?"

"I don't know," Jeff barely answered, too tired to tell her that although her information was wrong, her sense of impending catastrophe was all too on-target.

He slept fitfully the rest of the day, pestered and punctured by a procession of interns and orderlies bent on waking him up, taking his temperature, and telling him he needed more sleep. He asked for a TV or radio at least five times and got nothing. The phone by his bed was broken. He couldn't tell whether the morguelike atmosphere was standard or a consequence of the assassination. The assassination—every time he thought of it, he felt like retching. A leaden, queasy thickness of despair seemed to hang over everything.

He fell asleep at last into something deeper that let him dream. He watched a team of 19th-century surgeons, long

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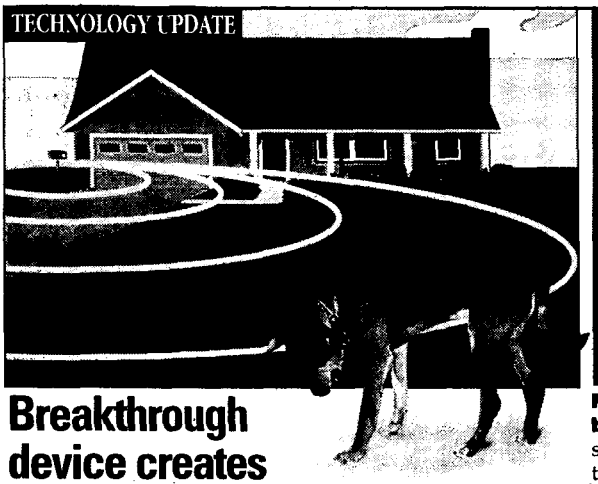
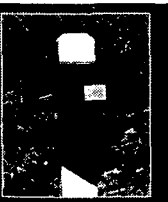
TECHNOLOGY UPDATE





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hair and whiskers with a bittersweet alcohol smell in the room, work over what must have been a very important patient. Straining his head closer, he could see that the patient was a fish, cut open and spread apart down the middle. The chief surgeon produced a mallet and began pounding the fish, while others cut off pieces and put them in little bags. "Oh, I'm only joking, old boy," the surgeon turned to Jeff and said in a crisp British accent, "this is dinner, of course!"

Jeff sat up sharply in bed, awakened by yet another nurse come to stick something in him. "What do you want now?" he rasped, wincing from the pain that came as he propped himself up.

"Just some intravenous for the evening, Dr. Harris. It'll help you sleep." She wheeled some torturelike contraption over to him. She was a big-boned, handsome, light brown woman, about thirty-five, who spoke with a lilting accent.

He shook his head to clear some of the cobwebs. "I already ate your lousy supper. Why do I need intravenous?"

"Pity the nurse who has a doctor for a patient," she said in the mildly scolding tone of voice that seemed a part of every nurse's repertoire. "Now why don't you just lie back like a good boy and let me get this working." A strong arm pushed Jeff back gently but firmly, and she began applying alcohol to his skin.

Once again the door flung open, this time admitting two burly black men carrying an impossibly fat TV set.

"I tell you what, Nurse, ah, Daniels." Jeff freed himself from her grip. "I'll take this intravenous only if it's prescribed and administered by an intern or resident. So you want me on that, you call in a doctor, fair enough?" This should buy him a little time to think this through. There was something he didn't like about this nurse, not to mention that he wasn't particularly partial to the prospect of being festooned with intravenous needles and tubing, 1960s style, carrying who knew what kind of viruses and subvees they didn't even know about back here, and he might not have been inoculated against.

Daniels looked at the two men hooking up the TV set and then back at Jeff. "No meat off my behind, honey," she said, and abruptly wheeled the equipment out the door.

Good—she'd apparently decided it wasn't worth making a scene in front of the techies. "Thank you, gentlemen," Jeff told them as they finished up. "See? It's not true what they say about the media always causing problems. Sometimes a TV can be very helpful."

They looked at him as if he was crazy, and left.

Jeff pivoted gingerly in the bed, placing his feet on the floor in slow, exaggerated motions. Pushing himself up shakily from his seated position, he found he could stand. He walked unsteadily to a chair by the window, and sat himself down with the utmost caution. The pain he expected in his back was mercifully slight. He reached for the suitcase lodged neatly against the window and fished inside for his clothing. Thank God the case

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wasn't lost at the airport. And a good thing, too, that it had been programmed to open only in response to his and no one else's sweat. Otherwise he'd have had some explaining to do about some of the contents.

He had to get out of here right away. He had to get back to New York, back to the student lounge. He reached deeper inside the suitcase. The rough fiber of the janitor's uniform finally chafed his fingertips. He doubted that an NYU janitor looked anything like the hospital variety, but this was still his best choice. He dressed very carefully, praying that his body would hold up long enough for him to walk out of this horror-movie of a hospital—this horror-show of a world.

Suitcase under his arm, he tiptoed to the door and opened it a crack. His room seemed to be in the middle of a long, orange-pink tiled corridor that stretched in either direction with no one in sight. Peering out a bit more, he could see what looked like a nurse's station down to his right. He hesitated. His mind felt swollen and paranoid, he had no confidence in his judgments. He didn't feel good about just walking out, but he felt much worse about staying. He opened the door and strode as casually as he could to the left.

He slowly became aware of voices ahead of him. He took a few more steps, then stopped and listened. They were definitely moving closer. He looked down the corridor the other way. Too long a distance to try returning to his room. He glanced quickly around at the rooms within reach and tried the door of the nearest one.

Locked!

He tried another one.

Same result!

His hands grew moist and his head light and the voices louder. He felt nauseated, as if he was about to vomit and pass out. He breathed deeply, steadied himself, and tried another door.

It opened! He leaned against the inside of the door, thankful and quaking, until the entourage passed. From what he could hear, they seemed to be just a team of porters.

Relaxing a bit, he groped for the light switch to see whose room he was in. This was an extremely stupid move, he realized just as his hand flicked the switch, for the patient might well begin screaming. Fortunately the room seemed to be some sort of storage facility.

He looked around and stopped on a lumpy something stretched out in a far corner. Again his heart started pounding, for he suddenly was sure he was looking at a dead body. He forced himself to walk over and focus. The lumpy something was a long bag of stained linen.

He resumed his journey down the corridor, this time with a bit more assertion in his gait. He turned randomly down several connecting passages, passed several orderlies and nurses and made a point of not avoiding their gazes, and eventually wound up at what looked like a service elevator. The doors were open. He walked in, pressed Lobby, and hoped for the best.

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The elevator wobbled its way down, Jeff envisioning himself a dead man dangling from a slowly descending rope. The doors finally opened on a poorly lit hallway that said Ground Floor. He walked a few feet, and was glad to see the hospital lobby. He wondered why the act of leaving a hospital always felt like escape from a high-security prison.

He hailed a cab and told him take me to the airport. The cabbie talked Kennedy, but Jeff was too tired to give more than grunts in response.

He sank into bed in the motel room, utterly drained. He closed his eyes and saw again the lumpy bag in the hospital laundry room. It was a woman's body, face down, wearing only a 20th-century bra and shiny beige panties that clung tightly to her rear. She looked familiar. He turned her over and found eyes staring blankly up at his. He tried to scream, but his throat stuck. The eyes were Rena's.

He sat up in bed, broken out in a cold sweat, and shuddered for a long time....

I guess I'm not as cut out for time travel as I thought, he said to himself. But how could anyone know that beforehand? You had to actually live through these loops, bristling with serrations, to know the toll they took.

Twelve hours later, he was on a plane for New York. Staring out the window as the engines revved up, Jeff realized he was losing a golden opportunity to stop the killing of Lee Harvey Oswald. He looked at his watch. That would happen tomorrow. He toyed with the idea of making a last-minute dash from the plane and calling the Dallas police. He'd have plenty of time and . . . no! For once he'd do the cautious thing and return to New York and then 2084. No chance the police would take his call seriously anyway—just another crank come out of the now festering assassination woodwork.

Of course, a crank who knew about Oswald's murder would be someone Jeff would want to meet. Wasn't there some story that the Dallas police were indeed warned by someone about the shooting of Oswald? Was that someone Jeff? Or someone else on trespass from the future?

He fidgeted with his seat belt. Maybe the attempt on his life in the hospital last night—if that nurse with the intravenous was indeed trying to kill him—was intended precisely to stop him from interfering with Ruby's murder of Oswald. No, that sort of reasoning would get him nowhere. It was paranoid nonsense. Yet he was here on this plane leaving the scene of the crime of the century, when there were plenty of things he still might do....

The plane's lift-off ended his reverie. Jeff tried to direct his thinking to what awaited him—going back to 2084 with the Thorne, then in it once again, through a new AWH, and out again in 1985, the time he should have arrived in the first place, to stop the explosion of the *Challenger*. He stared steel-eyed out the window. No one could help JFK—that should have been obvious all along. You can't change history on that major a level.

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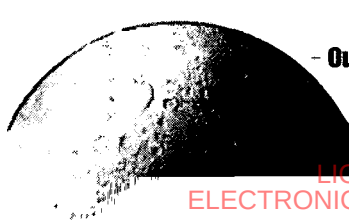

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But the *Challenger*—that was more mechanical, presumably an accident of technology, not of sick human intention, more amenable to the time traveler's ministration.

That was what he kept telling himself, but it gave him little comfort. Obviously, traveling back to 1985 wasn't as easy as he and his team had thought—if it was, why was he here? There were things about time travel they didn't understand.

He laughed bitterly. The last thing he wanted to be was a "Fourth Magi"—that additional wise man from the East who had gotten a late start in his journey to give the infant Jesus a gift. The potentate then spent the next thirty years in a vain search for Jesus, always arriving in places a few hours after Jesus had left. When he finally caught up it was too late—Christ was already on the cross. Just as Jeff had been with JFK. Would he be that way with the *Challenger* too? Arriving just in time to see that horrendous explosion that took so much else with it? Impotent witness wasn't the role Jeff had trained for.

He landed at Idlewild in the early evening. The sadness in the air was thicker than pollution. Soon it would harden into the cynicism and outrage that disrupted the sixties and deformed a good deal more of the times that came after.

It's not my fault, Jeff kept telling himself. My job was to stop the *Challenger* tragedy—I never really had a chance to stop what happened in Dallas. I wasn't properly prepared. It was crazy even to try.

He took a cab back to the Village, the same trip he had taken forty-eight hours ago, in reverse. Everything was different. It was Saturday night, and throngs of people were out, but the sounds and colors were drained of vitality—as if someone had pulled the plug on the watercolor, and all of its light had leaked away.

His cab pulled up to the Student Building. Three green-and-black police cars huddled like ugly roaches near the entrance. Students were milling about, five or six officers were conferring on the side, and the night air crackled with the sound of police bulletins and the glare of pulsing lights.

"What's going on here, Officer?" Jeff demanded, more sharply than he'd intended.

"Who the hell are you?"

Jeff fumbled for his faculty ID, crafted to look like a 1985 edition, and hoped it would get by the beefy, florid-faced policeman. "Sorry, Officer. I teach at the College of Liberal Arts and Science here."

The cop eyed the ID, Jeff, and softened. "You're a teacher from another division?"

"Right," Jeff said, not really knowing what that meant.

The cop nodded. "The student lounge was broken into two hours ago and severely vandalized. These kids got no respect for property. Hey, Professor, you OK?"

Jeff felt his knees buckle. He reached out to the police car for support. "Officer, I've got to get up there right away. I . . . there are some important papers that I must get a look at."

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He was pleading.

"Out of the question." A big arm restrained Jeff, already in motion towards the building. "The place is a mess. Glass and garbage all over. Someone torched that whole floor—probably some kid didn't like his grades. Believe me, Professor, it's not safe."

Jeff pulled free of the blue arm. For a second he considered making a run to the building. But he knew it was hopeless. He hadn't the vaguest idea what was really going on, what had happened in the lounge. But he knew with cloying certainty that his life was now seriously derailed.

Maybe the AWH had imploded, maybe some kid had torched the place as the cop had said, but whatever had happened there was no way that soft shimmering light would be there for him—surely no way he could code it for use and enter it even if it was there now, without a dozen witnesses looking on. A few dozen bills out of time he could take a chance on leaving back here; walking into the AWH with 1960s people as an audience, maybe even trying to follow, was insane. He couldn't risk what that would do to reality—might do to his very existence.

So he turned and walked shakily down the street. The cop might have said something but he couldn't hear it. The off-key amusement park quality of the Village congealed now into a proper smarmy nightmare. Jeff staggered a bit farther, then grabbed on to a corner lamp pole. Then he leaned over and did what he had wanted to do for nearly two days: he threw up what seemed like every ounce of substance in his stomach.

He looked at the mess he had made on the street, and wondered what part of that food might have come from 2084. It would be a long, long time if ever, he knew, before he was likely to see any of that again.

A Beatles song was playing somewhere in the distance. A DJ was talking. No historical moment, no hushed build-up. Just the Beatles. . . .

Jeff opened his eyes. He looked out of his window at the street below. Mid-April sunshine coated the sidewalk like clarified butter.

". . . Traffic light in most places but still heavy on the Kosciuszko Bridge," the radio continued. "H0A halfway through the third shift with you on WABC. Good morning!"

Jeff hoisted himself out of the easy chair. His clothes felt stale and rumpled—he had spent the night in them—and he needed a shave. He stripped, showered, shaved, and approached the pile which served as his wardrobe closet. Today would be a special day. He put on a blue button-down shirt, dark brown corduroy slacks, and pulled his navy-blue knit tie into a loose fitting double-Windsor, the only kind of knot he knew how to make. He slung a corduroy jacket over his shoulder and ambled down the three flights of stairs.

Jeff played with his scrambled eggs at the Yorkville Restaurant and considered his situation for a thousandth time. He pushed three pieces of egg to one side. His arrival twenty-three years earlier than planned, the lug-

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gage accident in Dallas, the destruction of the student lounge—were these all related, or three pieces of random, rotten luck?

He couldn't accept his being a Robinson Crusoe in the past. He understood his predicament, his utter stranding in the 1960s, logically enough. And yet some part of him had waited these past five months, hoping that one of his team would one day miraculously appear to rescue him. He'd imagined Rena in this role, but how could she? The mouth to 1963 had been sealed with the implosion or trashing or whatever had taken out the lounge. He'd been back up there several times, when no one was around, but the lounge had been totally reconstructed, with no sign of the AWH.

The team had no way of knowing he was even here—presumably all they would know is that he hadn't succeeded in stopping the *Challenger* disaster. If they sent anyone else back, it would likely be to 1985, where he was supposed to have gone, not here. And who knows if Rena or whoever would succeed any better than he. Maybe Steven Hawking was right in his chronology protection conjecture—maybe the Universe protects itself from alterations via time travel—removes unwelcome Thornes from its side—whether by misdirecting travelers, blowing up AWHs, both, more.

So he was probably stranded. But maybe not totally without options. He had to gingerly probe the contours of time travel—see just what small things it might allow, and then perhaps he'd try a few larger things. What he had in mind for today was the first modest step in this direction.

Jeff paid for his breakfast and walked out into the cool morning sunlight. His money problems were finally over—he had a job with a decent salary. Some parts of the team's exhaustive planning had worked out after all, had survived his immersion in a time twenty-three years earlier than expected. Their massive search of historical records had uncovered fourteen Harrises who had done graduate work at universities in the mid-20th century. One, named Geoffrey, had earned a Ph.D. in social psychology from the University of Edinburgh in 1958. The names and academic disciplines were close enough that Jeff, with a mixture of Geoff's credentials and his own knowledge of the field, would have been able to demonstrate a convincing identity in 1985-86—the team's reason for coming up with this. But it turned out to also be enough for Jeff to land a job back here as an Adjunct Professor at the third school whose ad he'd answered—his act sufficiently polished, hinting just enough knowledge of new trends in the field to kindle admiration without suspicion. It was a last-minute spring teaching appointment, to fill in for a regular professor unexpectedly on leave, that required only cursory credentialing. But it was a foot in the door, and it paid real money.

He squinted at the Sun and inhaled deeply. The polluted air still bothered him, and he sometimes felt as if little pieces of black soot were burning holes in his chest. He wheezed slightly. But the day felt promising, even

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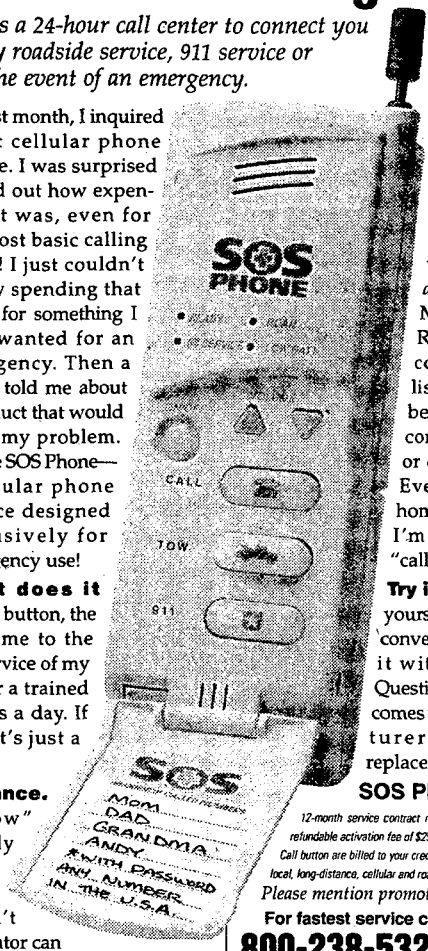

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beautiful, and he caught the cross-town bus to the IRT subway on West 86th Street. This would take him to the "Intro to Sociology" class that he taught at City College on 137th Street in Harlem.

Farther up the subway line, near a place called Pelham Parkway in the Bronx, Mrs. Sarah Harris also made her way to work. The day was beautiful to her too, and she also wheezed a bit—from asthma—as she walked down the block to Saperman's Bakery where she worked behind the counter. Her mind was filled today, as it was on many days, with images of the Ukrainian countryside around Kiev, and with pictures of her father. She could see him as clearly as if he were standing right in front of her, even though she had last seen him more than sixty years ago and a continent away. Her brown eyes, still keen and always wise, glistened a drop, not from soot but sentiment. Those eyes were almost identical to Jeff's. She was his great-great-grandmother.

At City College, in a place presciently named Harris Hall, Jeff labored to make a concluding point about McLuhan. "So you see, it's not what we watch on television that's important, it's the fact that we're watching television—rather than reading a book or listening to the radio—that McLuhan says really counts. This is what he means by 'the medium is the message.'"

Jeff looked at the students, most of whom were scribbling his words without the slightest comprehension. The three girls from Queens who smiled at him certainly hadn't the vaguest idea what he was talking about. Neither did the foreign kid, his mouth continuously hanging open, who at least made no attempt to disguise his puzzlement. But a few in the class did seem to have some understanding of what Jeff was saying. The girl in the back with the soft brown eyes seemed to be in touch with him. Anyway, Jeff liked the way she looked at him.

"OK, that's about it for today. Read the pertinent sections of *Gutenberg Galaxy,* and I'll see whether I can get you some advance copies of *Understanding Media.*" Jeff grabbed his corduroy coat and strode out the door, smiling at the girl with the soft brown eyes.

He hurried to the subway at 137th Street. He looked at his watch—the flector model, for Jeff no longer cared about keeping such minor aspects of his cover. In fact, he hoped future artifacts like this might attract someone's benevolent attention, maybe someone else from the future, who could help him. He'd have gladly kept spending his 1980s money too for the same reason, had he not been afraid that sooner or later some good Samaritan would have him arrested for counterfeiting.

It was 11:56—more than enough time.

But the subway took longer than expected, and it was 12:35 when Jeff ran down the long flights of stairs at the Pelham Parkway station in the Bronx. Saperman's was only a few minutes away by foot, so Jeff wasn't

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too worried. Still, he half-walked, half-ran.

He was sweating when he reached the bakery. He realized this was more from anxiety than exertion. His great-great-grandmother had died in 1992, at the age of ninety-seven. His grandfather, whom Jeff had spent some of the most satisfying times of his childhood with, had been just six when Sarah Harris had died. But grandpa carried memories of her warmth and voice and summers they had spent together in their cottage on Cape Cod Bay, and Jeff felt he knew Sarah through this.

But he stopped, suddenly not sure he could do this. What would he say to this woman? How would she react? A smell of apple strudel permeated his thoughts—grandpa's strudel, an old family recipe grandpa had loved to bake—and this gave him courage. He walked in.

"Hello," he said in the direction of the three matronly women who stood behind the counter and looked up at him as a clanking bell on the inside of the door announced his presence. Not a single one of them looked anything like his great-great-grandmother. "Can I help you?" one of them said in a soothing Jewish accent that he'd heard only in the movies.

"Uhm, yes . . ." he began, not quite sure what to say. "Does a Mrs. Sarah Harris work here?"

Just then he heard a rustle from the back. His great-great-grandmother walked out from behind a curtain, carrying some sort of cake in an open box.

"Sarah, a *botchik* to see you," one of the women said with a laugh.

Jeff felt like shouting with joy. He suppressed this, along with the urge to jump over the counter and hug her. She looked great—like her best picture, from a bar mitzvah of someone named Sol, come to life.

Sarah was smiling, a wonderful smile he had seen in his father and some of his aunts and uncles and his grandfather. "You look like I know you," she said. "You're one of Louie's grandsons?"

"Right, Louie," Jeff answered quickly. His mind sped through family history. Louie was Sarah's older brother. The two had come with a middle brother—Hymie—to New York around 1900. Sarah was a little girl then, about five, and Louie was like a father to her. Her real father and nine other brothers and sisters she would never see again. Louie—Uncle Louie, Jeff's grandfather had always called him—had moved to the West Coast after World War II. He had fathered a big family himself, and Jeff recalled that these in turn had given Louie dozens of grandchildren who from time to time showed up at weddings and bar mitzvahs on the East Coast. Good. Jeff for now would be one of them.

Sarah took off her apron and moved out from behind the counter. "I'm taking the rest of the afternoon off," she said to the matrons. "You tell Murray I'll make up the time this weekend, OK?"

"No, no, please, Mrs. Harris," Jeff raised his hand and smiled. He didn't think he could take more than a few minutes with his great-great-grand-

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mother in this first meeting. "I've got just a little over an hour before an appointment downtown, and I don't want you to lose time from your job. How about we go for a cup of tea at the Dairy Restaurant by Lydig Avenue? It's kosher, right?" He had checked out this whole neighborhood a week ago.

Sarah laughed heartily. "It seems you know me and this area very well. OK, let's go to Lydig. Tell Murray I'm back in an hour," she said over her shoulder to the counter.

"So it seems you know my name but I don't know yours," Sarah said as the two walked the half block around the corner to Lydig Avenue.

"I'm Jeff. Jeffrey Rosenberg." Jeff was 99 percent positive that Rosenberg was Sarah's maiden name.

Sarah's eyes widened in pleasure. "Yosef was the name of my father. Wonderful of Shlomo to name you after him. We have only one son, and we named him after my husband's—Yitzhak's—mother. So you're Shlomo's boy, then?" Now Sarah's eyes furrowed in some confusion. "Or are you Harry's?"

Jeff smiled and thought frantically as they entered the restaurant. He ushered Sarah to a table, and once seated, ordered two cups of tea—with lemon for Sarah, milk for him—from the elderly waiter who looked like he had about five minutes left to live.

He knew that Sarah prided herself on perfect recall of every relationship in her extended family. Right now she was probably realizing that as far as she knew, Shlomo had no son named Jeffrey, and neither did Harry. Jeff breathed in sharply. Time to talk about the impossible.

"I'm not really Louie's grandson," he said slowly.

In another time and place—in fact, in most times and places, including this one—such an admission would have been cause for alarm for Sarah. But her powerful intuition told her this was not a stranger to be feared—not a stranger at all.

"You're much closer to me than Louie's grandchildren," Sarah finally said. Her eyes looked loving, not challenging, to Jeff.

"You've traveled very far in your lifetime, Sarah," Jeff said softly. "Do think it might be possible to travel across years, across time, just like you've traveled across great distances?" The tea arrived.

Sarah chuckled. "You mean like angels? Or maybe like the *meshugenas* on the *Twilight Zone*?" She pronounced the "w" like a "v," so the show sounded like *Tvilight Zone*.

Jeff couldn't help laughing. He would have sworn that the only TV this woman would have ever watched, other than the news, was the *Lawrence Welk Show*. "Yes, something like that." Jeff felt much better after laughing. He put his teacup down. "Sarah, I'm going to tell you something now. You're a very intelligent women, and what I'm going to tell you will seem totally crazy. But please hear me out. It will take just a minute. And then I'm going to ask you to do a very important favor for me. You don't have to agree now, but please promise me that you'll think about it."

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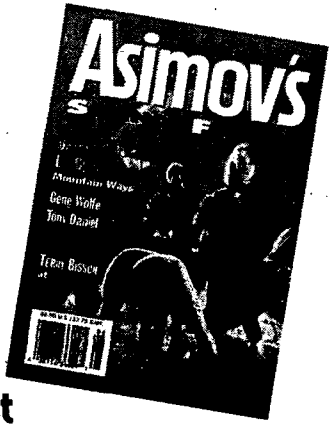

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"It's about what Hitler did in Europe?" she asked with a cry in her voice. Her hand shook, and she spilled some of her tea, though the cup was only half full. Jeff suddenly felt very guilty. His great-great-grandmother looked so much younger than he had pictured her, seen her in most of her pictures, that she had seemed at first not so old to him. Now she looked every one of her sixty years, and Jeff felt terrible that he was stirring up these demons about the Holocaust and who knows what else. But he had to finish what he had started here.

"No, it's not about Hitler." He paused. "I'm your great-great-grandson, Jeffrey Harris."

A small shriek came from Sarah, and the blood left her cheeks. "Sarah, please." Jeff took her hand. "I have to leave now. But I need you to do something for me that is very very important—my life may depend upon it. In twenty-five years, you'll get to know my grandfather, when he was just a little boy and you'll be much older." Jeff realized there were tears in his eyes. "And you'll be a wonderful grandma to him, believe me. But I want you to promise that you'll tell him—your little grandson—about this meeting. I'm not asking you to believe me now. You can tell your grandson that you had this meeting with a crazy man who claimed to be your great-great-grandson years ago. But everything depends on your telling him something—something about me, about this—twenty-five years from now."

Sarah's head shook—not no, but from tremors. Her eyes were a confused mixture of anger, uncertainty, love. Now she slowly shook her head no. "I don't know you," she whispered.

"I know. But I'm part of you—I'm your DNA, your blood." Jeff stood up, then leaned over and kissed her. "I love you, Sarah, I always will. Go by your instincts in this." He put a five-dollar bill on the table, and hurried out the door.

Now the April breeze caught his face, seemed to move him along. He walked in a daze, not really knowing where he was going, to the Pelham Parkway station. He paid his fare, walked through the wooden turnstile—nearly getting a splinter in his thigh—and sat down on the rotting green bench to wait for the train.

And then he remembered. His grandpa swinging with him on the hammock. Talking about a summer he'd spent years ago when his grandma was still alive, on Cape Cod. He was four, maybe five, so it was 1990 or 1991. His parents and little sister had gone out to Cooke's for supper. He'd had a bad cold, and had to stay in the cottage. Grandma Sarah stayed with him. It had started raining—very hard—an August Cape Cod storm that seemed to drench the beach and every living thing. And she told him about the strange man who had come to her long ago in Saperman's, the bakery where she used to work. . . .

Jeff shook as he recalled his grandfather's words. Thank you, Sarah—you came through for me. He felt like running back and hugging her, but didn't dare, lest this somehow throw a curve into what he had just accom-

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plished here.

He was sure this memory of what his grandfather had told him about what *his* grandmother had told *him* hadn't existed before. It proved that he was real in this convoluted past—that he could do things here which could indeed change the future, even if the change was as slight as a grandmother's words in a Cape Cod storm some sixty years before he'd been born. But those words, his memory of his grandfather's conveyance of them, meant everything. Sarah Harris had given him his first real hope. If he could change the future through her, he could figure out a way to somehow contact his team, and get back to where he belonged.

He was crying. For he also realized that in a deep, indescribable way he missed Sarah Harris even more than his world of 2084, and he knew there was no way he ever could have both.

"I think he's very attractive," Carla Caplan of Flushing said. "You know, not in the Marlon Brando or Paul Newman way, but in a cuddly way. Like a teddy bear." She stroked her left thumbnail with an emery board.

"Oh, I don't know," Amy Jacobson replied. "His accent is a little strange. And anyway, he never pays any attention to us. The only girl he ever looks at is the girl in back of the class."

Carla moved her hand along the nylon stocking on her leg. "That's not true, Amy. I've seen him look at us lots of times."

"The two of you are ridiculous." Sandy Greenfarb shook her curly brown hair. "Besides, teachers don't date students in this pathetic school. City College is too old-fashioned for that."

"Who said anything about dating?" Carla replied. "And you're wrong, anyway. Didn't you hear about Atwick in the bio department? They say he got a girl pregnant. Put some Spanish Fly in her drink."

Sandy blushed. "That's absurd. And anyway, Professor Harris is nothing like Professor Atwick. He's much more refined—more of a gentleman."

"How would *you* know?" Amy jumped back in.

"No one knows much about Professor Harris. He just started teaching here this term," Carla said.

"He's not married. That's all Carla needs to know." Amy laughed.

"Shh," Sandy said as Jeff walked into the room.

"Late as usual," Amy whispered.

"Well, I've read through most of your papers." Jeff slouched into the chair on wheels and stretched his feet out on the desk. "And I'm afraid to say that they were more gruesome than I expected."

A murmur of irritation rippled through the class.

"Now to begin with . . ." Jeff began, as one student, even later than he, hurried through the door. It was the girl with the soft brown eyes, who bit her lower lip in an apologetic smile and slipped into a rear seat as inconspicuously as possible.

"Miss, uh . . ." Jeff inquired, returning the smile.

"Laura Chapin."

"Yes, uh, Miss Chapin, I was just telling the class that most of these pa-

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pers on the McLuhanesque interpretation of the Beatles missed the point entirely. But there were a few exceptions. And yours was among the most refreshing."

Amy shot an I-told-you-so glance to Carla.

Laura's eyes dilated with delight. "Thank you."

Jeff finished the class five minutes early and headed quickly out the door. "Professor Harris," Laura called after him. He stopped a few feet down the hall and turned to face her. Jeff realized she looked taller and older than he had thought, her brown hair jostling invitingly around her shoulders. "I wanted to thank you for what you said about my paper," she said, slightly out of breath.

"You earned it. You have a fine mind."

She smiled without looking too embarrassed. "I was wondering if we might be able to get together and talk sometime—in your office—I, um, have some questions I'd like to go over with you about grad school."

Jeff looked at his watch and gestured Laura to walk with him towards the stairs. "Look, I'd ask you to join me for lunch right now, but I've a departmental meeting to attend. Why don't we have lunch together next Monday?"

Now Laura's face flushed a bit. "I... that would be very nice, but I've got labs starting at noon that run to four o'clock. Do you think it might be possible for us to meet in your office at 4:30 on Monday?"

Jeff stopped and looked steadily at Laura for a moment. Those eyes were alluring. "Monday at 4:30 it is, then," he said crisply, and strode away.

"I almost didn't keep our appointment today," Jeff said, sipping the third glass of red wine he and Laura had partaken since they'd adjourned their meeting from his office.

"Oh? And what possibly could have kept you?" The wine had lowered Laura's voice to a quiet, warm contralto. The cafe, five minutes on the subway from his office, had the smell of fine spirits and food.

"I didn't want the aggravation," Jeff said.

Laura considered his deadpan face, then burst out laughing. "Well, thank you very much."

"What would you say if I told you that I could predict the future?" Jeff asked offhandedly, taking another sip of his wine.

"You mean in a socially forecasting way?"

"I mean in every way."

"Well, Professor Harris, you told us in one of your lectures that for very good reasons no one can ever really know the future. So I would say either you were lying . . . or speaking metaphorically."

"Good," Jeff nodded, "but let's say I stubbornly insisted that I did know the future, and that this in no way contradicts what I said in my lecture about no one ever being able to know the future. What would you say then?"

"I'd say you were kidding me or crazy." Laura thought for a bit. "I don't think the future exists yet—it doesn't exist until it's actually created,

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in the present—so there's no way you or anyone could really know it in the way that we know we're here in this little bistro on Broadway, for instance."

"Fair enough." Jeff waved to the waiter for another round of wine. "You're sharp. But let's say I were to tell you that Lyndon Johnson will beat Barry Goldwater by a landslide this November?"

Laura shook her head. "No. Not good enough. Everyone expects Goldwater to get the nomination, and there's no way that Johnson won't win big what with the Kennedy sympathy vote. You'd have to do better than that."

Jeff smiled and rubbed his lips with his fingers. The Beatles's "Thank You, Girl" played languorously in the background. "OK, how's this: Let's say I tell you that in about a year and a half from now, the Beatles will have a hit record called 'Help' from a movie by the same name?"

Laura laughed. "You've got imagination, I'll say that for you. But I still don't think I'd be convinced. How do I know that you're not a personal friend of George Martin's with some special information about the Beatles's plans?" Laura frowned for a moment then snapped her fingers. "No, I've got it! You tell me what number on Billboard's Hot 100 a *non*-Beatle record—one that won't almost certainly make number one—will be in 1966, and I'll believe that you know the future!"

Laura extended her hands in a triumphant gesture, pitching over a nearly full glass of red wine onto her shirt in the process. Jeff jumped up, napkin in hand, and began patting Laura's soaked sleeve dry. He progressed from her sleeve to her cheek, and suddenly was less than an inch from Laura's upturned face. Her eyes were rosy with wine, her mouth soft and parted. He touched his lips to hers, gently at first, then found himself lost in a realm of warmth and darkness. . . .

He finally pulled away. "Well," he managed, gasping a bit for breath, "no one can ever say that I don't give my students personal attention."

"I'd be glad to write you a letter of recommendation," she said, smiling. "Now you see why I didn't want to have lunch with you."

"You found this aggravating?"

"Quite the opposite," Laura replied.

Still standing over her, Jeff touched her hair with his finger. "I've got a lot I need to tell you," he said softly. "By the way, no one but a record producer would know the exact number on the charts of a record even now, so your test of my knowledge of the future is too demanding."

They walked hand in hand a few evenings later along groves overlooking the Hudson River. Across they could see the Palisades of New Jersey, carved whole out of stone as if by some supreme civilization, and near them the palette of Wave Hill Park in the late spring. Wave Hill—home of Mark Twain, of Toscanini, and an Easter parade of a notables across a century. In the late 1800s, William Appleton had lived here, amidst his publication in America of Darwin and Spencer. JFK had lived in a house across the street in

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the 1930s. Recently a British ambassador had donated most of this to the people of New York.

Jeff knew it wouldn't especially help his larger predicament to get involved with Laura, to tell her what he was about. On the other hand, what harm could it do—set in motion a jagged time-loop which would wink him out of existence? Not likely. And the smell of her neck and his need to talk had been compelling. So he'd told her. And here he was, still around, and feeling fine.

He breathed in slowly. Fragrances real and recalled bathed his brain. "You know, when I was a kid, my grandfather used to tell me about summers he spent on Cape Cod when he was a kid himself. At night, sometimes two or three in the morning, he'd walk along the beach and gradually leave his cottage in the distance. Sometimes he'd turn around and, still seeing the light of the cottage, would walk further until it was completely gone. Then he'd close his eyes and think, there's no difference between what I see with my eyes open and my eyes closed. He'd sit in the salty water, a foot or two deep, and feel the cold fluid pulse of the cosmos throbbing through his clothes. Then he'd get up and walk again, cold but not shivering, until he made contact with that spot of light that was his cottage. He was never sure until it happened that he would see that light again. But when he did, he'd walk with the satisfaction of knowing that after having gone out to the very limits of his usual reality and beyond, he was about to enter it again. I never really fully understood what my grandfather was saying to me—until now."

Laura looked at him, stroked his face with the center of her palm. "You're serious about this, aren't you?"

"Serious about what?"

"The time travel," Laura said.

Jeff said nothing.

"I can be with you anyway," Laura said. "I don't have to believe it's real. I can pretend to believe it's real, play along that you're from the future, like you say you are. I'm not sure there's all that much difference between really believing and pretending to believe anyway, if you pretend sincerely enough."

"You've got some philosophy there," Jeff said.

Laura took his hand, put it to her lips.

"And you're not worried that I really *am* crazy—maybe dangerous?" Jeff asked.

"Oh, you're dangerous all right," she said, grazing her teeth over his index finger. "And as to your story—my feeling is that whatever the truth of it, you're a good man. I feel right about that."

Jeff sighed. "You remember what I said the first day of class about no one really knowing for sure that anything is real—we could well be dreaming all of this, and might even dream that someone pinched us and tried to awaken us and nothing happened—but that we'd all go crazy unless we took at least some leap of faith, and assumed on nothing better than faith that the world is real and we were really here?"

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"I was late for that lecture, wasn't I?"

"No, I'm quite sure you were there," Jeff said. "Look, I'm trying to say that—"

"I know what you're saying." Now she looked at him very intently. "You want me to take that leap of faith with you and your story. You want me to assume that what you're saying is true, even though I have no evidence for it and it flies in the face of reason. You want me to say, look, I know this is crazy, but I'm going to give you the benefit of the doubt, entertain your insanity, see where it leads us. In other words, pretense isn't good enough for you—you want to make this really hard for me." She turned away.

"Something like that, right," Jeff said.

"What is it about me that's always attracted to lunatics?" she murmured. She turned around and kissed him full on the lips.

"Two papayas." Jeff held up two fingers to the man at the Papaya King on 3rd Avenue and 86th Street. "One to drink here and a quart to go." There was nothing like this drink in his century. Whatever the hell it was—whatever its special mixture of pulp and sugars—it was delicious.

He walked down 86th Street, package in hand, towards his place by the East River. His place . . . he was feeling more and more comfortable in this place, and that made him feel uncomfortable, out of place. There were things he missed from his world—faces on the phone, words on the screen, poles of the planet as easily accessible as the north and south parts of this borough—but he missed them less and less. Especially when he was with Laura.

Still . . . he picked up a copy of the *Daily News*. Johnson was on the cover, saying he was going ahead full force on the space program, and on the inside was a picture of Gus Grissom. Jeff had thought about doing something to prevent the fire that would kill Grissom, White, and Chafee in their Apollo 1 capsule on January 27, 1967. But that was still over two and a half years away, and he couldn't be sure what impact that might have on the Moon landing, which was still the lonely high watermark of human penetration of space. No, he didn't dare mess with that—better to bide his time, and wait the nineteen further years, almost to the day, for a chance to avert the *Challenger* catastrophe, and the fatal blow it had delivered, in retrospect, to the space program.

But Jeff didn't suffer abidances of time very well. What was the point of time travel, anyway, if not to short-circuit ordinary time, make new things happen? It seemed the last thing that should be required of the time traveler was patience. Jeff knew now, ever since his experience with Sarah, that he could change the future—which meant that his existence here could make a difference. But he had to get some word back to his team in 2084. How? He'd even tried taking a page from Asimov—what was that book, *The End of Eternity*?—and placed small, discreet, but clearly informative ads in a variety of significant journals and newspapers like *The New York*

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Times. But nothing had happened. He had no idea whether any of the ads had even come to the attention of the team—1964 was after all well before the age of on-line information, and an ad in a newspaper this old might well have slipped by the Big Scannings in the new millennium.

He opened the door to his apartment quietly, so as not to wake Laura. She'd been sleeping over a lot, and Jeff figured she'd be moving in with him soon. He wasn't sure how his colleagues at City College would take this—the 1960s were one of the decades of sexual liberation, but Jeff wasn't enough of an expert on that aspect of popular culture to know just how far that went.

He tiptoed into the bedroom. He liked looking at Laura when she was sleeping. Her eyes were open just a crack, and he could see the bottoms of her soft brown eyes tracing some sort of REM-dream diagram. He hoped it was of him. He looked at her body, her breasts, one nipple partly exposed. He could do a lot worse than spending the next twenty-three years with her.

He walked carefully back into the kitchen, put the papaya juice into the refrigerator—he loved it, a living antique, right out of the Smith-Sonyian—and took out some eggs. Was cholesterol *verboten* in this decade? He'd been meaning to ask Laura. It certainly wasn't in his. He started a pot of water boiling for the eggs, and sat down at the table to read the paper.

"Jesus!" he shouted.

"What's the matter?" Laura shuffled out of the bedroom, rubbing her eyes.

Jeff shook his head in shocked disbelief.

"What's the matter, honey?" Laura walked over, put a concerned hand on his shoulder.

Jeff pointed to the paper.

"What? What is it?" Laura asked.

Jeff jabbed at a picture. "I know her," he rasped. "She was a member of my team. Rena Sarrett."

Laura leaned over, and read aloud the article associated with the photograph. ". . . Run down by a bus on Central Park South last week . . . died the next day . . . her co-workers say she was hired by Gaulin's, an insurance firm, about six months ago . . . attempts to locate Miss Sarrett's relatives have all proven unsuccessful . . . police would appreciate anyone with information contacting them. . . ."

"She was part of your project?" Laura asked.

"Right," Jeff said, his voice choked with emotion.

Laura had the presence of mind to turn off the water, which was furiously boiling. "And you and she were lovers?"

"What?" Jeff croaked.

"I'm sorry," Laura said.

"Yeah, we were lovers. Once. A long time ago—actually, in a time which doesn't even goddamn exist yet. Does that matter?"

"Did you love her?" Laura asked.

"Yes," Jeff said, tears in his eyes. "But not as much as I love you."

Laura put her arms around his neck, stroked his chest. "That's all that matters to me. I love you too."

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Jeff rubbed the side of his face against her hand.

"What does this mean?" Laura asked. "I mean, your friend getting killed. . . ."

"It means they sent her back too—maybe to find me here, who knows, maybe they got one of my messages after all," Jeff said. "Or maybe they were trying to send her back to 1985, to do the same job I was supposed to do, but for some reason she got sucked back here to the 1960s too. I don't know."

"What are you—we—going to do now?" Laura asked.

"I don't know," Jeff said.

"I don't really want to go to this party," Jeff said, trudging reluctantly after Laura up a steep street in Washington Heights.

"Come on." Laura turned around and pulled his hand. "It's been over a month since you found out about Rena, and all you've been doing is moping and brooding—it's time you got out and saw some people. It's summer already, for God's sake."

"Not moping—thinking," Jeff said. "I was knocked unconscious in Dallas, Rena was killed by a bus, both in places we shouldn't have been. There's got to be some comprehensible pattern in this."

"I know," Laura said, more softly. "It's almost as if there's something in the nature of things that doesn't want people to time travel—and punishes them when they do."

"You know I dreamed about Rena dead, shortly after I got out of the Dallas hospital," Jeff said, recalling this for the first time. "I wonder if that has any connection to any of this."

"Well, remember you told me that Kip Thorpe—"

"Thorne," Jeff corrected.

"Right, Kip Thorne and his people hypothesized that people flip into alternate universes when they change history through time travel—that that's how the loops opened by the Thorne stay clean—so maybe, somehow, because you're here in the past, you've caused an alternate universe to come into being, and in that universe you already lived past knowing about Rena's death, because that universe is progressing at a different pace, and somehow your dream connected you to this alternate version of your self. . . ."

Jeff smiled. It was at times like this that he could understand how he had come to feel so close to Laura. "You don't think I'm such a lunatic anymore, huh?"

Laura snuggled against him. "You're definitely a lunatic—no doubt about that—but maybe not about time travel."

Jeff kissed her on the forehead.

"Well, here we are at Joannie's building," Laura said. "Don't worry, I'm sure there'll be other teachers there. Just think of this as another great safari into 1960s culture."

"What can I fix you, Professor?"

"A scotch and water would be fine." Richard Atwick adjusted his thin-rimmed glasses and quietly eyed the hosed legs and sleek red dress of his benefactor. "Why, thank you, Carla," he said, taking the drink from her hand, "and I must say you're looking

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as lovely tonight as always."

He gulped half his drink down in one swallow and, sloshing the rest around in the glass, began walking through the six rooms of Joannie Pernelli's parents' apartment. The place was packed with partiers in varying states of dress, intimacy, and inebriation.

"Professor Harris." Atwick strode over and extended his hand to Jeff. "I've seen you around campus, but I don't think we've ever formally met. I'm Richard Atwick of Biology." He suddenly put his hand to his ear as the Beatles's "It Won't Be Long" blared forth without warning.

"Nice to meet you," Jeff said loudly over the twanging guitars. "Do you know Laura Chapin?"

"I don't think so, but I'm glad to now." Atwick said. "Are you doing graduate work?"

"Thanks for the compliment." Laura smiled sweetly. "But I'm afraid I'm still undergrad. And if you two gentlemen have no objections, I think I'll go off and mingle now with some of my own kind."

"Nice." Atwick watched her walk off and nodded at Jeff approvingly. "And what are you having to drink, Professor?"

"Please, call me Jeff." Jeff tried not to respond to the nod. "I guess I'll have some white wine if there's any around."

"Well, let's just go and find some, shall we?" Atwick tugged on Jeff's arm and started towards the bottles on the far side of the room. "You know, I'm delighted that you'll be joining us again this fall in the Sociology Department. Sociology—that's a discipline of the future! It's good we're building up our faculty in that area."

"Well, I'm happy to be here at City College. It's certainly one of the best schools in the country."

"Well, we like to think so." Atwick beamed. "Ah, here's some sort of Soave. Will that do? Good." Atwick began pouring. "Now I've heard your specialty is mass culture. And you did your graduate work at . . ." Atwick handed Jeff a brimming paper cup.

Jeff sipped a little and spilled a little on his shirt. "University of Edinburgh. And my specialty's really mass media—you know, the work of Marshall McLuhan—rather than mass culture." Jeff got a pang as he thought again about how he had successfully recycled the cover the team had provided—any thought of the team brought along painful images of Rena. . . .

"Edinburgh, yes," Atwick was saying. "Splendid mountain in the middle of the city. You worked under Phillip MacKenzie?"

"Mackenzie? Nope, don't think I did," Jeff said, wondering what he would say next if pressed. His credentials, after all, would not stand up to anyone who knew the real Geoff Harris, or even very long to anyone who knew someone who knew Geoff. . . .

The sound quieted down a bit, and it occurred to Jeff that Atwick had a familiar British accent, maybe like a surgeon he half-remembered hearing once in a hospital. . . .

"Of course, it's a large university—" Atwick began.

"Professor Harris, it's good to see you outside of the classroom!" Carla

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joined the men. Jeff was delighted for the intrusion.

"You know, I'm really *mad* at you for that C+." She batted her eyelids flirtatiously at Jeff.

"Well, Carla, if Professor Harris had graded you for good looks, I'm sure you would have received an A+. Am I right, Jeff?"

"Absolutely," Jeff said—thinking that, if his grasp of history was right, in a few decades that kind of bantering could bring both Atwick and him up on sexual harassment charges. He shuddered. Insane days they were, at the end of the 20th century. He'd be doing the world a big favor if the only thing he did back here was change *that*. . . .

"Aw, I can't stay mad at you guys, you're too charming," Carla mewed. "Do you believe in dancing with students, Professor Harris? Professor Atwick has already honored me with one of his cha-chas."

Atwick bowed. "The honor was all mine."

"Well, I'd be pleased to dance with you, Carla," Jeff laughed, "but I'm afraid these new dances are too much for me."

Carla smiled and subtly shifted her body so that her curves were more prominent. "I was thinking of something nice and slow."

"Well, in that case, I'd be a madman to refuse." Jeff winked at Atwick and extended his arm to Carla. He looked in vain for Laura as Carla escorted him to a room in which "The Best of Johnny Mathis" played incessantly.

An hour and who knows how many red dresses later, Laura came up behind Jeff. "Hi," she whispered in his ear and kissed it. "Find out anything interesting?"

"Actually, yeah," Jeff said, and handed Laura a glass of wine. "Amazing how many people seem to know the future when you're primed to hear that in their conversation. One kid told me that he thinks the Beach Boys will go on to become second only to the Beatles in musical importance. Now how could he know that on the basis of 'Surfin' Safari' and a couple of other uncreative songs in 1964?"

"Tall blond, sun-tanned boy, Mark?" Laura asked.

"Yeah, I think so."

"Well, he looks like one of the Beach Boys, so maybe he's just self-impressed," Laura laughed, and spilled her wine. "Oops."

"You've got no luck with wine, have you?" Jeff was laughing too, now. He had to admit he was having a good time. "Here, take mine. I just poured it. I'll go get another."

"I think I've had *fantastic* luck with wine at least one time," Laura said.

Jeff went to fetch another bottle in an adjacent room. The music there was louder than anywhere else. Jeff cringed a bit under the sound assault, then realized he was hearing something else mixed in with the music . . . a piercing wail coming from the next room. He dropped the bottle and ran in and found Laura shrieking on the floor.

"Laura, what's the matter?" He lifted her face and looked intently into her eyes. They were grossly dilated. Her shrieks suddenly turned into hysterical laughter.

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"Professor Harris, is she sick or something?" Sandy, who Jeff realized had been standing over them, was nearly in tears herself.

"I don't know, Sandy. Look, could you please call me a cab?"

Jeff helped Laura to her feet. She was screaming and yelling at the top of her lungs but Jeff couldn't make out what she was saying. She passed out in his arms in the elevator. He carried her into the back seat of the cab that arrived a few minutes later. "Get me to the closest hospital emergency room," he told the driver, who looked as if he'd seen it all.

He carefully put her head on his lap and wiped big beads of sweat from the bridge of her nose. Her eyes were tightly shut and she drooled slightly from the corner of her mouth. He gently wiped that also. She was moaning and half-singing some Beatles song.

He had read of the effects of sixties psychedelic drugs on people—assuming that's what this was, though it seemed a little early in the 1960s for that—and could see this was a very bad reaction, likely from something more nasty than LSD. Who the hell had given it to her?

In his day and age, treating it by simple suffusion would be child's play. But here, more than a century earlier, with no nano-syndics at all—jeez, he hoped these "doctors" were up to this. What would they use to cleanse her chemistry? He sighed, stroked her face. There was no point in torturing himself. That wouldn't stop her from dying. He had no choice but to put Laura in whatever primitive doctor's hands this cabbie placed her.

But why did this happen?

Another damn mishap?

He had a searing insight for an instant. Yes, of course. . . . But the cab swerved too sharply around some corner, and he lost it.

He looked down at Laura's lips, and trembled.

Jeff had always found strength in the rivers of New York. He had spent hours as a child wandering along the banks of the Bronx River—more a stream, really, than a river—admiring its waterfalls, sticking his toes in its pools, following its path through the Botanic and Zoological Gardens. Years later, he would sit on the terrace of Rena's high-rise on 125th Street, watching the powerful Hudson roll through the ninth decade of the stagnant 21st century. Good in medicine, agriculture, the intraphysics that the Thorne embodied, but not much else. Good in looking inward, backward, not outward. He walked now around Carl Schurz Park, looking down on the East River and its reflection of this 1960s city, hoping to find something he could use to recover his balance.

Laura was OK, resting in his apartment, well out of danger. That wasn't the problem.

"Close," the doctor had said. "Good thing you rushed her over here. Combo of booze and that kind of drug is dangerous. Good thing it responded to—"

Better get used to it, doc—you'll see a lot more of it before this decade is over.

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Thank God Laura was OK.

But Jeff wasn't.

He had slept maybe an hour after bringing her home from the hospital, undressing her, tucking her safely in their bed. He'd had nightmares—older and younger versions of his great-great-grandmother coming in and out of his life, changing it with each appearance, editing the narrative that was him so many times that he had no bearings. Only alterations, of alterations.

Jeff had always valued the sanctity and clarity of his mind. That's why he'd steered clear of the psychedelic drugs of *his* century—better to improve external reality than just your perception of it. But he figured the contamination now of his past and future was far more toxic to the psyche than the worst drugs. Coleridge, de Quincey, Huxley, Leary, Goonatilake—you're all pikers compared to me.

But why was he feeling the brunt of this now?

Something Laura had said or done—not her almost ODing, but something that had happened then, though he didn't know what—had unhinged him—

"Hi, honey." A soft, cool hand touched his as he leaned against the stone embankment. He turned to Laura. She still looked pale.

"You shouldn't be out yet. How are you feeling?"

She held up her palms in an I-don't-know gesture. "I think pretty much better. I was going crazy in the house, and you were gone a long time. I was worried."

Jeff pulled her close. "Oh, Laura, Laura," he said softly, sadly. "What's going on?"

They parted and held hands, looking down at the lights that slid upon the inky water below. "I don't know," she said. "Do you?"

"I think so," Jeff said quietly.

"Tell me," Laura said.

"I think you know."

"No." Laura's face furrowed in confusion.

Jeff dropped her hand and turned to face her. "You look very nice in those shorts."

Laura patted the light red shorts she was wearing on this humid summer evening and looked even more confused. "What do my shorts have to do with anything?"

"For God's sake, stop playing games with me, Laura!" A nearby elderly woman with blue-tinted hair glared at Jeff. He glared back and lowered his voice. "Try being honest with me for a change."

She turned and looked out over the water. "I think I have been honest. I've told you how much I love you." Her voice was husky.

"I don't suppose you remember much of what you did when the DMT first hit you?" Jeff continued impassively.

"No, I don't remember much of anything. The whole experience was horrible. You know that." She started crying.

"So you have no idea what song you were singing when I took you home in the cab?"

She shook her head. "I can't believe I was singing in that state—"

"Well, would it surprise you to

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know that you were singing a few lines of the Beatles' 'Yes It Is' over and over again? 'Please don't wear red tonight. . . .'"

"And you place some sort of significance on this?"

"I've been driving myself crazy, wandering around here for hours, trying to figure out what's been bothering me ever since I heard you singing those lines. I didn't even know until I saw you and your red shorts a few seconds ago that that song was the problem. But now I'm starting to understand. You still want to claim you have no idea what I'm talking about?"

"I haven't the foggiest notion." For the first time, annoyance was in Laura's voice. She had stopped crying.

"I think you do. Do you know what today's date is? June 29, 1964. Now the Beatles have released two albums in America so far, *Meet the Beatles* and *The Beatles' Second Album*. Actually, they also have a third album on VeeJay Records with some early songs. There's also an album with songs from their *Hard Day's Night* movie and a few new songs, *Something New,* which will be released here in a couple of weeks. You see I know all of this because I taught history of rock for five years when I first got my Ph.D."

"I know all about your past and future," Laura said tartly.

"Good." Jeff grabbed her arm and raised his voice again. "And do you also know that 'Yes It Is' is on none of those albums? None of them! And in fact it won't be heard in America until an album called *Beatles VI* is released sometime late next year?"

Laura pulled away and laughed sarcastically. "And that's what all this is about? That when I was stoned out of my mind on some Brazilian drug maybe intended for you I sang some song that won't be released in the US for another few months? There are a thousand explanations for that. I might know some English guy who heard Lennon and McCartney perform that song in a personal appearance. You yourself might have sung the song in your sleep. What's the big deal?" Her voice was rasping, and she started to cough.

"Your life's at stake," Jeff said. "That's the big deal. Don't you get it?"

Laura just looked at him, eyes wide and brimming with tears. She started to walk away.

"Listen to me, goddamn it!" Jeff caught up to her, spun her around, put his hands heavily on her shoulders. "Rena died. I think I was almost killed. You were almost killed. These are serious forces we're playing around with here."

She turned her head away, as if from the intensity of his reasoning.

"Tell me the truth!" he demanded.

"I love you," Laura said.

"We need more now," Jeff insisted.

Laura exhaled, squeezed close to Jeff, then pulled away. "It's getting windy out here," she shivered. "Let's go back to the apartment and I'll try to tell you as much as I can."

The kettle whistled. Jeff carefully poured the water into the porcelain teapot, let it warm a bit, then added two servings of Darjeeling tea and the extra one for the pot.

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Laura was on the couch, arms around her knees and legs tucked under, talking. "We knew there was danger right after the arrival, but we didn't think it continued years after."

"None of the little expeditions before mine ran into any trouble at all," Jeff said. "As far as I know, I was the first not to return—the first whose AWH self-destructed, or was destroyed by something else, after my time jump."

"None of those little events before yours were intended to seriously alter history," Laura said. "Your *Challenger* attempt was the first big-scale operation."

Jeff felt cold, and touched the teapot for warmth. The number of lives lost in the *Challenger* explosion—if only he hadn't been funneled back here to the 1960s. . . . "Suppose you start at the beginning," he said, "though it still bothers me to talk of beginnings that in one sense haven't even happened yet."

"The gist is this," Laura said. "My team was—will be—situated about fifteen years after yours in the future. We knew about your team. Knew about you, Rena, her getting killed here. When your team uncovered her death in a cache of old microfiche, they stopped the project. Sealed all the files. *My* team found out about it and decided, secretly and illegally, to reopen it. My job was to—"

"Don't tell me—to stop the killing of JFK."

"No," Laura said.

"But you're here in the 1960s," Jeff said.

"My job was to keep an eye on you—assuming I could find you," Laura said.

Jeff's mouth hung open. "They sent you back here to find *me?*"

"Actually, not back here—to 1985," Laura said.

"But—"

"Right," Laura said. "But I wound up back here, just like you, and just like Rena. My team didn't understand that at first. Neither did I. But I think it's clear what's going on now. The Thorne operates by creating basins of subatomic attraction, at both ends of the artificial wormhole. But if you create enough artificial basins, all in one place, that in effect must begin to operate like one hugely powerful natural basin, attracting all out-of-time units in its temporal vicinity. Like a well-worn ditch attracting rivulets of water."

"Three were intended to go back to 1985 . . ." Jeff mused.

"Yes," Laura said, "and they all ended up here more than twenty years earlier. Think about it. Your team perfected time travel, tried to bury it, my team dug it up—you can't as a society, a species, unlearn a kind of knowledge. There must be thousands of time travel operations throughout the future. And a likely place for many of them to focus is JFK—first assassination on film, on tape, copied onto digiscan, holoscan, mirrorims, and who knows what new media. It's the cultural icon of assassination, the beacon against which all others are measured."

"The glittering prize for time travelers," Jeff said, bringing Laura her tea.

"Yes," Laura said, gratefully sipping. "And pulling any other time travel-

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ers back here who happened to be floating around nearby in time-flux," Jeff said.

Laura nodded. "Look at this very year—1964. The Beatles, Bob Dylan, Marshall McLuhan—the sexual revolution, feminism, the ecology movement all get big boosts in the next few years. Why all of that packed into this one decade? Couldn't be coincidence. The answer is that the 1960s were infected—and inspired—by time travelers. Despite all of our attempts at curbing possible cultural contamination from the future, it can't be done. You've seen that. Some leaks out—and causes massive cultural upheavals."

"John Lennon was a time traveler?" Jeff asked.

"I don't know, maybe," Laura said. "Maybe that's why he was murdered. At very least I'd say he was touched by time travel."

Jeff's head was reeling. Someone else who didn't deserve to die, whose death he'd like to prevent if he could. Surprise Lennon's killer in that Dakota alley, break his goddamn gun-hand.... Was Jeff bound to spend his whole life now as a shackled witness to history? "How'd you find me?"

"Wasn't too hard," Laura said. "Once I got back here, realized I was stranded, I figured I might as well see if you landed back here too. We knew you were a teacher. You had to live, earn money somewhere. So I went around to every school in the area, saying I wanted to be a sociology major, and asking for information about the faculty. This was my plan for 1985, so I had some good credentials ready, made them just right with a little alteration. And when I talked to your chair at City College, I knew I hit pay dirt—he showed me your outline, and its emphasis on McLuhan. McLuhan's been well known in Canada for over a decade, but not down here."

"Why didn't you tell me who you were?" Jeff asked.

"I didn't want to spook you—have you run away on me, where I couldn't find you again."

"Good you succeeded in at least one thing," Jeff smiled tiredly.

"Yeah."

"With all the people who came back to save Kennedy, not a single one succeeded at that, did they?" Jeff asked.

"No," Laura said, "at least not as far as we know in our universe of knowledge." She shook her head. "I really do think that there's something about history that resists attempts to change it."

"Hawking's Chronology Protection Conjecture?" Jeff said. "Thorne and his colleagues claimed to have refuted that, though I admit the math was a bit beyond me."

"Refuted in theory—with the assumption of clean loops with no causality interference—but loops are much dirtier in practice, especially with big events affecting so many people like assassinations," Laura said. "Attempts to change those either fail completely, or maybe just change the events a little bit—or cosmos forbid, maybe even ironically set up the events to happen in the first place."

"Not to mention that they're hazardous to the health of the time travelers," Jeff added.

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"You really think we're in danger?" Laura asked.

"Obviously. My guess is the Universe sort of cleans up after itself—does what it can to make sure there aren't too many loose ends, joints out of time, around at any one time. From that perspective, we're irritants to the Universe—our very being here disturbs it. But that doesn't mean we'll definitely be killed. Maybe we're just, I don't know, accident prone, more likely in a statistical sense to meet harm than others. If we're really careful, maybe we'll live. After all, you and I are still alive and kicking."

Laura pulled him down next to her on the couch.

Jeff's mind flipped back to the images of the *Challenger*. "It's so frustrating. To be back here, and not be able to even do anything about it. I mean, we have almost twenty years to plan some sort of intervention—maybe we can do something, something small that won't rock the boat too much, but just enough to deflect the disaster, or the worst of it." He saw the faces again. "Over a hundred kids were killed when the *Challenger* crashed into that schoolhouse near Miami. The kids dead, the astronauts dead, those images and flames burning into everyone's brains all over America and the world—no wonder it stopped the space program dead in its tracks. No president or Congress could support it after an accident like that—even dictators couldn't force it on their people—"

"What did you say?" Laura looked at him.

"What? About the *Challenger*?"

"What do kids in a schoolhouse have to do with that?" Laura asked.

Jeff looked puzzled.

"The *Challenger* explosion was a terrible thing for the country, and the space program, yes," Laura said. "It was horrible—everyone saw those seven astronauts walking to their death, waving to the cameras, right on television. But it blew up just a minute or so after launch—nowhere near Miami or a school filled with kids."

Jeff gasped. "And the space program continued in your timeline?"

"Oh yes," Laura said. "I mean, it's got its problems. Serious ones. But we've got settlements on Mars and the asteroid belt and—"

And for the first time since he had stood in front of the NYU Student Building with police lights mocking him in the night, Jeff had more than a whisper of hope.

"Maybe the difference between your version of reality and the one I remember," he said, "is us." ■

Prosperity is only an instrument to be used, not a deity to be worshipped.

—Calvin Coolidge

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Charles Sheffield

DEUS EX MACHINA

A new perspective on the future of computers—including us!

You can't really write *an* article on computers. It's like writing a single article on astronomy, or physics, or chemistry. There is so much to say, a thousand books can't say it all.

And in the case of computers—particularly if we are interested in the *future* of computers—matters are much worse.

Astronomy is as old as human history, and probably older. Mathematics, physics, and chemistry go back at least to Archimedes, in the third century B.C. Biology and medicine certainly pre-date Hippocrates, who lived around 400 B.C.

Computers, even if we are generous with our chronology, stretch back at most to about 1832, when Charles Babbage began to formulate his ideas for a computing machine—an "analytical engine"—which he was never able to build. In terms of practical experience as to what a general purpose computer can do, we are limited to the half-century since ENIAC began operations, in 1946. Computers are close to the beginning of their evolution.

If we have a large set of data points on a graph and ask where the next points are likely to lie, we can do a fairly good job. We fit curves to the given points, and extrapolate. When we have just a couple of points, the task is impossible. We lack the information to decide which fitted curve is appropriate. With a short history, our curve of projection can go almost anywhere.

To see how computers have changed just one world—the world of science fiction—recall that Robert Heinlein and Isaac Asimov, to name two of the field's most scientifically responsible writers, assumed that their heroes would be carrying slide rules around with them in the far future. The slide rule went the way of the dodo in the early 1970s.

How long before our style of personal computer shares history with the slide rule? No one knows.

What can we do? We can pick a few particular topics within the vast general field of computer development, and say a few words about them. The topics described here reflect my personal interests.

* * *

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Speed Limits.

In the years since 1946, the speed of electronic computers has increased by a factor of two every two years. There is no evidence that the rate of increase is slowing down. By 2006, machines a billion times as fast as ENIAC will exist.

Between 1946 and 1950, a handful of machines were built. One famous projection, by the management of IBM, estimated that a total of five computers would serve the total needs of the United States. Today, restricting ourselves to general purpose computers, and ignoring the ubiquitous special purpose machines that inhabit everything from thermostats to automobile fuel injection systems, several hundred million machines are in use around the world. Many ordinary households have more than one computer. I had to pause to count, before I realized that here in my house as I write (on a computer, of course) there are seven working machines. It was eight machines until a couple of months ago, when I threw away a computer purchased in 1981 which, although still working, was hopelessly out of date.

Not only speeds and numbers of machines have changed. Consider storage. The first machine for which I ever wrote a program was called DEUCE. It was big enough to walk inside. The engineers would do just that, tapping at suspect vacuum tubes with a screwdriver when the electronics were proving balky. Machine errors were as common a cause of trouble as programing errors; and the latter were dreadfully frequent, because we were working at a level so close to basic machine logic that today the machine would be considered impossible to program.

DEUCE had 402 words of high-speed (mercury delay line) memory, and 8,192 words of back-up (rotating drum) memory. The machine that I just threw away had several times that much storage. There were no tapes or disks on DEUCE, only punched cards for input and for intermediate or final output.

Today, it is a poor personal computer that does not have several hundred million bytes of disk storage. Applications programs have expanded to fill the space available. The word processing language I am using requires five million bytes. I'm not sure what it does with them, because I stay several layers of programming languages away from the basic machine instructions.

Costs have been coming down too, to the point where the choice, to buy or to wait, is not an easy one. We know that in a year's time we will receive several times as much capability for today's price. Costs have decreased in about the same way that speeds have gone up. We receive a billion times as much computing for a dollar as we did in 1946.

Where will all this end? There must be limits to speed of performance and memory, but the past half century is no help at all in defining them. We must look elsewhere for the limiting variables.

Physics provides two seeming limits. First, there is a definite relationship between the frequency with which something oscillates, and the associated energy. Specifically, $E = hf$ where E is energy, f is frequency, and h is Planck's constant.

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If we are performing 10^{15} operations per second, the associated energy is about one electron volt. Noting that the binding energy of electrons to atoms is just a few electron volts, we see that higher speeds than 10^{15} operations a second will ionize atoms and rip them apart. Here, then, is one apparent limit that we will not easily be able to surmount (but may eventually; for some of the wilder options, see Moravec [1988]).

The speed of light provides a second limit. In order for the computer to function, electrical signals (which travel at light speed) must be able to pass from one component of the computer to another. Since the speed of light is about 300,000 kilometers a second, in 10^{-15} seconds, the time for one operation, a light-speed signal will travel only 0.3 micrometers. A hydrogen atom is about 10^{-4} micrometers across, and all other atoms are bigger; therefore, in 10^{-15} seconds light travels only a distance of at most a couple of hundred atoms. If we could make components that small (currently we cannot) then again we would have a limit of 10^{15} operations a second.

To set this in perspective, there are computers today whose circuit speeds approach a trillion operations a second. We seem, at last, to be able to make a definite statement: computers have a limiting speed of operations that is no more than a thousand times what we can achieve today.

But wait. This speed limit assumes that operations are done *sequentially*, one after another. This is known as serial operation. Many of today's fastest machines employ *parallel* operation, in which many computations are done at the same time. For example, suppose we have to multiply one column of N numbers by another column. Since the N results are independent, with N multiplier units in our computer we can do all N multiplications in the same time as one multiplication.

There are machines today that perform over a hundred thousand operations in parallel. This pushes the potential speed of operation of a machine up by a factor of 10^5. Is there a limit to the degree of parallelism that can be achieved in computation?

It is difficult to see one. We do know that the limit is far higher than 10^5; the human brain, with its 10^{11} neurons, has slow "hardware." The discharge/recharge rate of a neuron is no more than a thousand times a second. But a human (and many animals) can process an image received from the eyes, and recognize a particular individual's face, in less than a tenth of a second. That is less than one hundred "hardware cycles." Our computers require hundreds of millions of hardware cycles to do the same task, and do it less well. We have to conclude that some huge parallelism is at work in both human and animal brains.

Even without considering radically different methods of computing (which we are now about to do), we see no limits to computational speed.

Biological Computers.

We now consider two new approaches to achieving high parallelism. Both are at the limit of today's science. Some people would argue that the biological comput-

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ing of this section, and the quantum computing of the next, are beyond the limit.

First, a few words about DNA. *Deoxyribonucleic acid*, universally shortened to DNA, was discovered in 1869 by the German chemist Friedrich Miescher. It was (and is) found in the nuclei of the cells of living things, but initially no one knew its structure, what it did, or how important it was.

DNA is one of a class of chemicals known as *nucleic acids*. By the beginning of the twentieth century, the components of the DNA molecule were known to be sugars, phosphates, and two types of two chemical bases known as *purines* and *pyrimidines*. The functions of the molecule were still obscure, though in 1884 a zoologist, Hertwig, had written that it was the way that hereditary characteristics were passed on from generation to generation.

He was right, but most people didn't accept what he said. So when, in 1943, Erwin Schrödinger gave lectures in Ireland on the mechanisms of heredity, he did not talk about DNA. He proposed, in his lectures and in a book *What is Life?* (Schrödinger, 1944), that the basis for heredity must be some kind of code, in which specific sequences of chemicals were written and interpreted; however, he assumed that the "code-script," as he called it, was contained in proteins, in the form of an aperiodic crystal.

Schrödinger was right, in that heredity, and all cell reproduction, depends on what we now term the *genetic code*. But it took another decade before the nature of the code and the structure of the code carrier were determined.

DNA, not proteins, carries the genetic code, for humans and for everything remotely like us. Nature is prodigal with DNA. In most (but not all; mature red blood cells lack a nucleus) of the 10^{14} cells of our bodies, we have the DNA to provide a complete description of the whole organism. Your DNA is in all important respects the same as the DNA in any other animal or plant, everything from a wisteria to a walrus. The same, that is, in all important respects but one: your DNA defines the unique you, the walrus DNA defines the complete walrus. In principle, given one cell from my body, a full copy of me could be grown (but not, of course, with my memories).

The structure of the DNA molecule was determined by Crick and Watson in 1953. It has the form of a double helical spiral. Strung out along the spiral, at regular intervals, are molecule after molecule of the four chemical bases. Their names are adenine, cytosine, thymine, and guanine, and they are exactly paired. Wherever on one strand of the double spiral you find a cytosine nucleotide base, paired with it on the other strand you will find guanine; if there is thymine on one strand, on the corresponding site of the other strand there will be adenine. If we were to read off the sequence of nucleotide bases along a single strand, we would find a long string of letters, A-G-T-G-C-T-A-A-C-C-G-T-A- (we are using the obvious abbreviations). The corresponding sites on the other strand would then, without a choice, read T-C-A-C-G-A-T-T-G-G-C-A-T-.

Long strands of DNA nucleotide bases, each base with an accompanying sugar and phosphate molecule, make up the *chromosomes* found in the nucleus

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of every cell. Individual genes, with which the science of genetics is mainly concerned, are subunits within the chromosomes. The division of the DNA into many separate chromosomes (humans have forty-six of them) seems to be mainly a matter of packing convenience. Efficient packing is necessary. There are about three billion separate nucleotide bases in human DNA, tucked into a cell nucleus only a few micrometers across. The chromosomes that define you totally are invisible to the naked eye.

The means by which the DNA molecule reproduces itself is simple and elegant: the double helix *unwinds*. One branch of the spiral goes in one direction, the other in the opposite direction. As each site on the helix is left with an unpaired base, the correct pairing, cytosine/guanine or adenine/thymine, takes place automatically (the pairs of bases have a natural chemical affinity). The correct base is collected from a pool of materials within the cell. At the same time, the necessary sugar and phosphates are added to the spine of the helix. When the double helix has finished unwinding, *two* new double helices, each identical to the original one, have miraculously appeared. The DNA molecule has reproduced itself.

That's all I can say about DNA (it, too, is the subject of a thousand books) except to note that the DNA molecule can be thought of purely as an information-storing device. That the DNA of our chromosomes happens to carry our own genetic code makes it of special interest to us, which is why we have a human genome mapping project; but in fact, any information at all can be stored in DNA. For example, let us treat the nucleotide bases, adenine (A), cytosine (C), guanine (G), and thymine (T), as codes for the numbers 0 to 3. Then we can write, using binary notation, A = (00), C = (01), G = (10), T = (11). The long string of nucleotide bases of a DNA molecule may then be thought of as a general purpose storage device. The computer stores information in binary form, as 0s and 1s. Any sequence of binary digits can be mapped exactly onto a sequence of nucleotide bases, and vice versa. For example, the digit string (11011001101010001111) is equivalent to (TCGCGGGATT). This is an extremely compact form of storage, since a few cubic centimeters can hold as many as 10^{18} DNA molecules. We also have techniques readily available for snipping, joining, and replicating DNA molecules.

So much for storage. This all seems interesting, but not particularly useful, especially since the process of storing and retrieving DNA-stored information is slow compared with electronic storage and retrieval. How can DNA serve as an actual computer, and how can it solve real problems?

The first DNA computer calculation was performed by Leonard Adleman (Adleman, 1994). The problem that he addressed was one in directed graph theory. We will consider here a slightly different and more familiar application. It is well-known and notorious in operations research and it is called the *Traveling Salesman Problem*.

Suppose that we are given a set of towns, and know the distance between every pair of them. We assume it may not be the same distance both ways, be-

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cause of bypasses and one-way streets. If a traveling salesman wants to visit each town just once, and return to his starting place, what is the shortest distance that he must travel?

For two towns, the answer is trivial. Similarly for three, where the town-to-town distances define a unique triangle. With four, five, and six towns, the problem becomes a bit more complicated, but it still seems easy. Here, for example, is the case with five towns, Hull, Hornsea, Beverley, Weighton, and Driffield, and their associated distance pairs:

	Hull	Hornsea	Beverley	Weighton	Driffield
Hull	0	17	10	15	17
Hornsea	18	0	6	12	20
Beverley	12	5	0	14	19
Weighton	12	11	14	0	7
Driffield	16	21	18	6	0

We read this as telling us that the distance *from* Hull *to* Weighton is 15 miles (first row, fourth column), while the distance *from* Weighton *to* Hull is only 12 miles (fourth row, first column).

There is a simple and absolutely guaranteed way of generating the best solution. Write down the five towns in every possible order, add up the distances for each case, and pick the shortest sum. We can reduce the work somewhat, by noting that it does not matter where we start; so the closed circuit Hull-Beverley-Hornsea-Weighton-Driffield-Hull must give the same total distance as Hornsea-Weighton-Driffield-Hull-Beverley-Hornsea. However, a path may not give the same distance as the reverse path.

Applying the writing-out method to this case, we have to look at 4x3x2x1 = 24 possible routes. The salesman's minimum distance is 50 miles, and his route is Hull-Beverley-Hornsea-Weighton-Driffield-Hull.

It may seem hard to believe, but if we specify not five but a hundred towns, the method we have proposed is too much even for today's fastest computers. It is easy to see why. It does not matter where we begin. So pick a town. Then we have 99 choices for the second town; for each of those we have 98 choices for the third town; then 97 choices for the fourth town, and so on. We have to evaluate a total of 99x98x97 . . . 2x1 cases. This number is called factorial 99, and it equals about 10^{156}. The lifetime of the Universe does not provide enough computing time to enumerate all the routes.

Of course, direct enumeration is a safe but not a sensible method. The actual approach to tackle the problem would use some variation of a method known as linear programming. Even this, however, will not give us an exact answer. We are forced to go to approximate methods that provide good (but not necessarily best) solutions.

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Now let us see how we might solve the problem with DNA computation. First, we give to each town a string of 20 DNA nucleotides. The number 20 is long enough to prevent confusion in the calculation. There is no difficulty if we preferred 40, or 100, or any other even number, but 20 is sufficient for this small example.

Here are suitable single DNA strands, where we have deliberately written each one as two ten-string pieces, and the gaps after the tenth nucleotide are introduced only for convenience of reading:

Hull	TCGCGGGATT AGACTGTAAG
Hornsea	GTTCGAAGTC AGTCGTACCT
Beverley	AGCTTATATC GGTATATGGC
Weighton	ATATGGCGAA CAGTCGTGCG

It does not matter what the particular strings look like, only that they be different. They can be chosen at random.

As we know, to every DNA string there corresponds a complementary string, in which the nucleotides (A,T) and (C,G) are interchanged. Together, a string and its complementary string make up a portion of DNA double helix.

The complementary single DNA strands for Hull, Hornsea, Beverley, Weighton, and Driffield, with gaps after the tenth nucleotide introduced for convenience, are:

Hull	AGCGCCCTAA TCTGACATTC
Hornsea	CAAGCTTCAG TCAGCATGGA
Beverley	TCGAATATAG CCATATACCG
Weighton	TATACCGCTT GTCAGCACGC
Driffield	GCCCTAATCT ATTAGTCCAT

Now we proceed as follows:

1) We copy the single strands for each town billions of times.

2) For each town pair, we make a 20-element strand using the *last* 10 elements of the complementary string of the first town, and the *first* 10 elements of the complementary string of the second town; thus, for Hull to Weighton the string is:

TCTGACATTC TATACCGCTT

3) We copy these complementary strands billions of times.

4) For each town-to-town pair, say Hull to Weighton, we take the associated distance (in this case, from the table of distances we see that this distance is 15).

5) Into the middle of each 20-element single strand made for each town pair, insert a line of paired nucleotides equal in length to the *distance* between that pair. For Hull to Weighton, we then have the string:

TCTGACATTC AAAAAAAAAAAAAAA TATACCGCTT
TTTTTTTTTTTTTTT

The string is a double strand in its middle, a single strand at its ends. Note

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that the strand corresponding to travel from Weighton to Hull is different than Hull to Weighton.

The strings were written with spaces only to make the structure easier to see. Leaving out the gaps now, we have for Hull to Weighton:

TCTGACATTCAAAAAAAAAAAAAAATATACCGCTT
TTTTTTTTTTTTTTT

We make such a DNA strand for travel from every town to every other. The length of any strand will be 20 + the distance between the pair (taken in the right order).

In our five town example, there will be exactly 20 strands, one for each element of the distance table.

6) Now we are ready to start work. We put all our town strands and our town-to-town complementary strands into a beaker, and stir gently.

What happens? As we know, complementary pairs have a natural affinity for each other. Any string, such as AGTC, will seek to match with its complementary string, TCAG, so as to form a double strand. A longer string will have to match base pairs along a greater length before a double strand can form.

Consider the strand for a particular town, say Weighton. Its strand is ATATGGCGAA CAGTCGTGCG. The last ten elements of the strand will seek to match their complementary strand, GTCAGCACGC. Such a sequence will be found at one end of every town-to-town string originating at Weighton, and it will link up to form a double strand over those ten sites. Suppose it links to the Weighton-to-Beverley connecting strand. The result will look like this:

(Weighton to Beverley strand, 34 bases)
GTCAGCACGC AAAAAAAAAAAAAA TCGAATATAG
ATATGGCGAA CAGTCGTGCG TTTTTTTTTTTTTT (match Beverley strand)
(Weighton strand) (distance 14)

The far end of the Weighton-to-Beverley strand will have an affinity for the Beverley strand, so it will link up with the first ten sites of that town. The last ten sites of Beverley will in turn seek out the first ten sites of another compatible town-to-town strand, whose last ten sites will link to another town (which could, of course, be Weighton again). The process will go on, adding town after town, unless the process terminates by a string "catching its tail," linking the final site back to the first one to form a closed loop.

Here, for example, is Weighton to Beverley to Hull, with Hull at the right-hand end all set to connect with some other town-to-town strand:

(Weighton to Beverley) (Beverley to Hull)
GTCAGCACGC AAAAAAAAAAAAAA TCGAATATAG CCATATACCG AAAAAAAAAAAA AGCGCCCTAA
ATATGGCGAA CAGTCGTGCG TTTTTTTTTTTTTT AGCTTATATC GGTATATGGC TTTTTTTTTTTT TCGCGGGATT AGACTGTAAG
(Weighton) (Beverley) (Hull)

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7) In our beaker we have endless billions of different DNA strings. We now sort them out chemically, according to the number of nucleotide bases in each. We can put an upper limit on the length of "interesting" strings. Any string that has more nucleotide base pairs in it than 100 (20 for each of the five towns) plus the sum of the five maximum distances, cannot be the solution we want. We reject all those strings and retain the others.

We also have a lower limit. Any string less than a hundred bases long cannot contain all the towns, so it can be rejected.

We return only strands of acceptable length to our beaker.

8) Now we unwind each of the double strands into its two separate strings. We want to find the shortest suitable strand, but to be suitable it must include a sequence of bases from each of the five towns (we might find a loop that went from Beverley to Hornsea to Beverley, total 11 miles and therefore total string length 51 bases, but it would be no good).

9) We introduce into our beaker of acceptable-length strands the *complementary* DNA string for each town. We do this for one town at a time. Thus, the complementary string for Hull is AGCGCCCTAA TCTGACATTC.

Anything with the single strand for Hull will attach to this complementary Hull strand. We separate out *only* strands with such complete Hull double strands. Into this beaker we introduce the complementary DNA string for Hornsea, CAAGCTTCAG TCAGCA-TGGA. Only DNA strands with the Hornsea DNA single strand will attach, so we can now separate only those strands containing both Hull and Hornsea complete double strands.

In the same way we use the complementary single strands for Beverley, Weighton, and Driffield, to generate strands that must contain complete double DNA strands representing all five towns.

10) Finally, we select out the shortest strands from all those that pass our tests. Such strands visit each town, and they do so with the shortest possible distance. Analysis of those DNA strands will tell us both the town-to-town route and the distance.

This may seem like an awful lot of work to solve a very simple problem, and of course for a small case like this the DNA computer is certainly overkill. With realistic quantities of DNA, we would find not one strand giving the solution, but billions or trillions of them.

That merely suggests we should be able to tackle much harder and bigger problems. Soon after Adleman's original paper, Richard Lipton pointed out how a DNA-based computer could address a difficult class of searches known as "satisfaction" problems (Lipton, 1995). Since then, biological computers have been taken seriously as a computational tool with great although unmeasured potential.

Quantum Computers: Making a Virtue of Necessity.

Computers, as they were envisaged originally by Charles Babbage in the first half of the nineteenth century and implemented in the second half of the twenti-

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eth, are deterministic machines. This happens to be one of their principal virtues. A calculation, repeated once or a thousand times, will always yield precisely the same answer.

However, as the size of components shrinks toward the molecular and atomic level, indeterminacy inevitably creeps in. The "classical" computer becomes the "quantum" computer, in which quantum effects and uncertainty appear. This is an absolutely essential and inescapable consequence of quantum theory, and if the components are small enough there is no way that quantum effects can be either ignored or avoided.

Is there any way we might make a virtue out of necessity, and use quantum effects to improve the performance of a computer? That question has been asked in detail only in the last few years, though Richard Feynman wondered about the possibility in 1985. The answer is astonishing: a "quantum computer" seems to be theoretically possible (none has yet been built), and its performance may permit the solution of problems quite out of reach of a deterministic, classical computer.

The classical computer is built from components that each have two possible states, which we might label as "on" and "off," or "up" and "down," or 1 and 0. Any number, as we remarked in discussing biological computers, can be written as a string of 1s and 0s, e.g. the decimal number 891,525 is (11011001101010001111) in binary notation. Binary to decimal and decimal to binary conversion is easy for any number whatsoever.

Our quantum computer will use as components individual electrons. Each has two possible spin states, which we label "u" and "d" for up and down. Twenty electrons would then represent the number 891,525 as (ddudduudududuuuudddd).

So far we seem to have accomplished nothing. However, recall that according to quantum theory an electron can be in a "mixed state," part u and part d. A mixed state with two components is termed a ***quantum bit***, or ***qubit***, to distinguish it from a classical binary digit, or bit. The classical binary digit is *either* 0 *or* 1 (u *or* d). The corresponding qubit is simultaneously 0 *and* 1 (u *and* d).

If we know only that the state of each electron is a mixed state, 20 of them—20 qubits—might represent 2^{20} different numbers. If we perform logical operations on the group of electrons, without ever determining their states, then we have performed computations on *all possible* numbers they might represent. Operations are being performed in parallel, and to do the same thing with a classical computer we would need 2^{20} processing units—more than a million of them.

The choice of a string of 20 electrons was arbitrary. We could have as easily chosen 100 qubits, or 1,000. That is still a tiny set, compared with the number of electrons in any electric signal. However, $2^{1,000}$ is about 10^{300}. We have a possible parallel operation at a near-incomprehensible level.

The principles described here are clear. Some possible practical applications

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are already known. For example, the parallel processing provided by qubits can be used to decompose numbers into their prime factors. This is a difficult problem, which with classical computers cannot be solved in practice for very large numbers. The computation time becomes too enormous.

However, we have skated over some of the difficulties involved with quantum computers. The worst one is the extreme sensitivity of a quantum computer to its surroundings. No computer can be completely isolated from the rest of the universe, and tiny interactions will disturb the mixed states needed for the qubits. This is termed the "problem of decoherence," and its practical effect is that any problem solved on a quantum computer must be completed before interaction of the environment causes decoherence.

Quantum computers are very much on the science frontier. Their development stage today may be like that of classical computers in the mid-1940s, when some of the world's smartest people doubted that a reliable electronic computer would ever be built—the failure rate of vacuum tubes was too high. Today, transistors and integrated circuits are so reliable that a hardware error is the last place to look when a program fails (the first place we look is in the computer program code, generated by that quirky and unreliable computer, the human brain).

Quantum Brains and Roger Penrose.

Today's computer is a completely deterministic device. Is the human brain one also?

Most workers in the field of Artificial Intelligence (AI) would answer, yes. Human brains are, in Marvin Minsky's phrase, computers made of meat.

In 1989, the English mathematician Roger Penrose made a radically different proposal. In a book that was a surprising best-seller, *The Emperor's New Mind* (Penrose, 1989), he claimed that some functions of the human brain will never be duplicated by computers that develop along today's lines. The brain, he asserts, is "non-algorithmic," which means that it performs some functions for which no computer program can be written.

This idea seems like scientific heresy, and it was received with skepticism and even outrage by many workers in the field of AI and computer science. For one thing, prior to this book, Penrose was very much one of their own kind. Now he seemed like a traitor.

What does Penrose say that is so upsetting to so many? In *The Emperor's New Mind*, he argues that human thought employs physics and procedures quite outside the purview of today's AI and machine operations. The necessary physics is drawn from the world of quantum theory. In Penrose's words, "Might a quantum world be *required* so that thinking, perceiving creatures, such as ourselves, can be constructed from its substance?"

His answer to that question is, yes, such a quantum world is required. To see the direction of his argument, recall that according to quantum theory, a parti-

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cle does not necessarily have a well-defined spin, speed, or position. Rather, it has a number of different *possible* positions or speeds or spins, and until we make an observation of it, all we can know are the *probabilities* associated with each possible spin, speed, and position. Only when an observation is made does the particle occupy a well-defined state, in which the measured variable is precisely known. This change, from undefined to well-defined status, is called the "collapse of the quantum mechanical wave function." This is a well-known, if not well-understood, element of standard quantum theory.

What Penrose suggests is that the human brain is a special kind of quantum device. In particular, the same processes that collapse the quantum mechanical wave function in subatomic particles are at work in the brain. When humans are considering many different possibilities, Penrose argues that we are operating in a highly parallel, quantum mechanical mode. Our thinking resolves and "collapses to a thought" at some point when the wave function collapses, and at that time the many millions or billions of possibilities become a single definite idea.

This is certainly a peculiar notion. However, when quantum theory was introduced in the 1920s, most of its ideas seemed no less strange. Now they are accepted by all physicists. Who is to say that in another half-century, Penrose will not be equally accepted when he asserts, "there is an essential *non*-algorithmic ingredient to (conscious) thought processes" and "I believe that (conscious) minds are *not* algorithmic entities"?

Meanwhile, almost everyone in the AI community (who, it might be argued, are hardly disinterested parties) listens to what Penrose has to say, then dismisses it as just plain wrong. Part of the problem is Penrose's suggestion as to the *mechanism* employed within the brain, which seems bizarre indeed.

As he points out in a second book, *Shadows of the Mind* (Penrose, 1994), he is not the first to suggest that quantum effects are important to human thought. Herbert Fröhlich, in 1968, noted that there was a high-frequency microwave activity in the brain, produced, he said, by a biological quantum resonance. In 1992, John Eccles proposed a brain structure called the *presynaptic vesicular grid*, which is a kind of crystalline lattice in the brain's pyramidal cells, as a suitable site for quantum activity.

Penrose himself favors a different location and mechanism. He suggests, though not dogmatically, that the quantum world is evoked in elements of a neuron known as *microtubules*. A microtubule is a tiny tube, with an outer diameter of about 25 nanometers and an inner diameter of 14 nanometers. The tube is made up peanut-shaped objects called *tubulin dimers*. Each dimer has about ten thousand atoms in it. Penrose proposes that each dimer is a basic computational unit, operating using quantum effects. If he is right, the computing power of the brain is grossly underestimated if neurons are considered as the basic computing element. There are about ten million dimers per neuron, and because of their tiny size each one ought to operate about a million

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times as fast as a neuron can fire. Only with such a mechanism, Penrose argues, can the rather complex behavior of a single-celled animal such as a paramecium (which totally lacks a nervous system) be explained.

Penrose's critics point out that microtubules are also found elsewhere in the body, in everything from livers to lungs. Does this mean that your spleen, big toe, and kidneys are to be credited with intelligence?

My own feeling is that Penrose's ideas sounded a lot better *before* he suggested a mechanism. The microtubule idea feels weak and unpersuasive. Like the Wizard of Oz, the theory was more impressive when it was hidden away behind the curtain.

My views, however, are not the issue. Is Penrose wrong, destined to be remembered as a scientific heretic? Or is he right, and a true prophet?

It is too soon to say. But if he proves to be right, his ideas will produce a huge change in our conceptions of physics and its relation to consciousness. More than that, the long-term future of computer design will become incredibly difficult.

With the latter point in mind, we might paraphrase Bertrand Russell. He said of Wittgenstein's theories, as we can say of Penrose's: "Whether they are true or not, I do not know; I devoutly hope that they are not, as they make mathematics and logic almost incredibly difficult."

Where are the Robots?

Science fiction writers did a poor job predicting the arrival of near-ubiquitous general purpose computers. What science fiction *did* predict was robots, mechanical marvels capable of performing all manner of tasks normally associated with humans.

Robots came into science fiction three-quarters of a century ago, in Karel Capek's play *R.U.R.* They have been a staple element of science fiction ever since. In the real world, robots have fared less well. Either they have been confined to the role of robot arms at a fixed location, performing a few limited operations on an assembly line; or they have been slow-moving, clumsy morons, trundling their way with difficulty across a simplified room environment to pick up colored blocks with less skill and accuracy than the average two-year-old.

What went wrong? And when, if ever, will it go right?

The big problem seems to be human hubris. We, aware of the big and complex brains that set us apart from every other animal, over-emphasize the importance of logical thought. At the same time, we tend to diminish the importance of the functions that we share with animals: easy recognition and understanding of environment, easy grasping of objects, effortless locomotion across difficult terrain.

But seeing and walking have a billion years of development effort behind them. We do them well, not because they are intrinsically simple, but because evolution has weeded out anything that found them difficult. We don't even

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have to think about seeing. Logical thought, on the other hand, has been around for no more than a million years. No wonder we still have trouble doing it. We are proud of our ability, but a fully evolved creature would find thought as effortless, and be as unaware of the complexity of operations that lay behind it, as taking a drink of water.

Recognizing the truth does not solve the problem, but it allows us to place emphasis in the appropriate area. For many years, the "difficult" part of making a robot was assumed to be the logical operations. This led to computer programs that play a near-perfect game of checkers and a powerful game of chess (Deep Blue lost to world-champion Kasparov early in 1996, but it would not have lost to me or you). At the same time, the program was as helpless as a baby when it came to picking up a chess piece and executing a move. Those functions were performed by Deep Blue's human handlers.

So when will we have a "real" robot, one able to perform useful tasks in the relatively complicated environment of the average home?

The answer is: when development from two directions meet.

Those two directions are:

1) "Top down" activities, usually referred to as Artificial Intelligence, or just AI, that seek to copy human thought processes as they exist today. AI, after a promising start in the 1960s, stumbled and slowed. One problem is that we don't know exactly what human thought processes are. As Marvin Minsky has pointed out (Minsky, 1986) the easy part is modeling the activities of the conscious mind. The hard part is the unconscious mind, inaccessible to us and difficult to define and imitate.

2) "Bottom up" activities, that start with the basic problems of perception and mobility, without introducing the idea of *thought* at all. This is an "evolutionary" approach, building computers that incrementally model the behavior of animals with complex nervous systems. We know that this can be done, because it happened once already, in nature. However, we hope to beat nature's implementation schedule of a few billion years.

When top-down and bottom-up meet, in what Hans Moravec refers to as the "metaphorical golden spike" of robotics (Moravec, 1988), we will have a reasoning computer program (or, more likely, a large interconnected set of programs) with a good associated "lower-level" perception and movement capability. In other words, robots as science fiction has known them for many years.

When?

Moravec says, in fifty years or so. He is perhaps not entirely impartial, but if we do not accept the estimates of leaders in the robotics field, whom do we believe? If you introduce working household robots into a story set in 2050, at least some of today's robotics specialists will offer you moral support.

In making his estimate, Moravec relies on two things. First, that the projections quoted at the beginning of this article on computer speed, size, and costs are correct. Advances in biological or quantum computers can only serve to

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bring the date of practical robots closer.

Second, Moravec believes that when the necessary components come together, they will do so very quickly.

We have to ask the question, what next? What will come after reasoning computer programs?

The optimists see a wonderful new partnership, with humans and the machines that they have created moving together into a future where human manual labor is unknown, while mental activities become a splendid joint endeavor.

The pessimists point out that computers are only half a century old. In another two or three hundred years they may be able to design improved versions of themselves. At that point humans will have served their evolutionary purpose, as a transition stage on the way to a higher life form. We can bow out, while computers and their descendants inherit the Universe. With luck, maybe a few of us will be kept around as historical curiosities.

All of this presumes that the development we describe next does not achieve the potential that many people foresee for it.

Artificial Life and Assisted Thought.

In 1969, the English mathematician John Horton Conway introduced a paper-and-pencil game with an appropriate name: *Life*. Given a large sheet of paper marked into small squares, together with a few simple rules, objects can be generated that seem to possess many of the attributes of living organisms. They move across the page, grow, reproduce copies of themselves and of certain other organisms, and kill other organisms by "eating" them. The game was a big success in academic circles, and computer versions of it soon appeared.

Slowly, through the 1970s and 1980s, the realization grew that computers might also be useful in studying life with a small "l." The behavior of competing organisms could be modeled. Those organisms could then be "released" into a computer environment and allowed to "evolve." The results would provide valuable information about population dynamics.

But must it stop there? If we take the next step, we already pointed out in discussing biological computers that the DNA of any organism can be put into exact correspondence with a string of binary digits. In a real sense, those digits represent the organism. Given the digit string and suitable technology, we could construct the DNA, introduce it into the superstructure of a cell, and grow the organism itself.

We could do that, but why should we bother? We know that computer circuits operate millions of times faster than our own nerve cells. Couldn't we take various kinds of DNA, representing different organisms, prescribe the rules within the computer for growing the organism, and let the competition for genetic survival run not in the real world, but inside the computer. Maybe we can in that way speed up the process of evolution by a factor of many millions, and watch the emergence of new species in close to real time.

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The practical problems are enormous. There is so much that we do not know about the development of a living creature. The necessary data must certainly be in the DNA, to allow an eye and a kidney and a brain to develop from a single original cell, but we have no idea how this "cellular differentiation" takes place. In fact, it is one of the central mysteries of biology.

Meanwhile, we look at another possibility. Suppose we were able to download into a computer the information content of a human brain. Now we have something that does not *evolve*, as DNA representations might evolve, but thinks in the virtual environment provided inside the computer. This is artificial life, of a specific and peculiar kind. For one thing, the speed of computer thought should eventually exceed the speed of our flesh-and-blood wetware by a factor of millions or billions.

Take this one step further. The size of computers constantly gets smaller and smaller. Already, we could tuck a powerful machine away into a little spare head room, maybe in one of the *sulci* of the brain or in a sinus cavity. Even if the machine lacked the full thinking capacity of a human brain, it could certainly perform the routine mathematical functions which for most of us are anything but routine: lengthy arithmetic, detailed logical analyses, symbol manipulation, and compound probabilities. (Maybe we should add elementary arithmetic to the list, since the ability to do mental calculations, such as computing change from twenty dollars, seems to be waning fast.)

Nature took a billion years to provide us with brains able to perceive, manipulate, and move our bodies with effortless ease. Maybe we can give ourselves powers of effortless thought, to go with those other desirable features, in a century or two. ■

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Grey Rollins

FIRE and ICE

To thrive, a colony must have something to sell—and its most valuable commodity may not be the most obvious.

Illustrated by Ron Chironna

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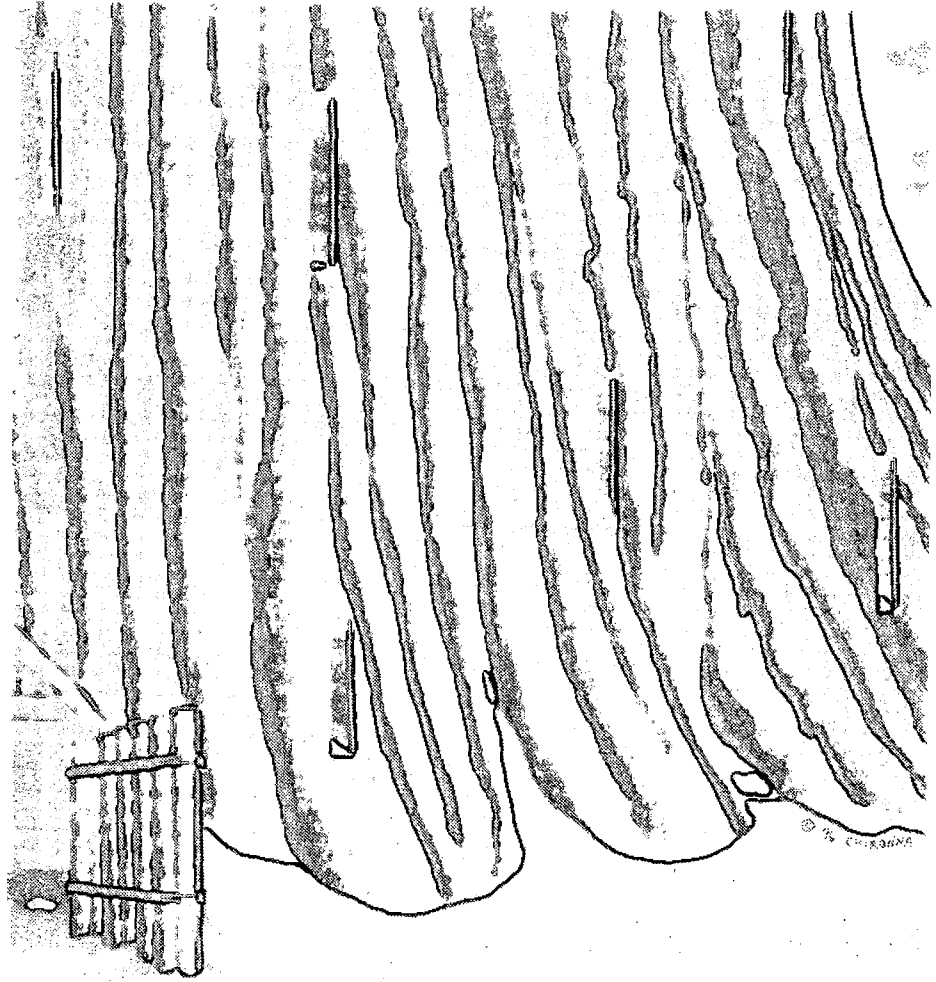

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I didn't want to go. It's cold, there's absolutely nothing to do, and I'd be stranded for at least three months while my faithless fiancee, Stephanie, danced her way through half the men in Miami.

But when my editor assigned me to do the article, it was either book passage or hit the road looking for a new job. Old news: jobs are hard to come by, unless you relish the idea of a challenging career selling shoes for a living.

I had the pool secretary call Delta for reservations.

Traveler of Worlds is a magazine with six editors. Every month each editor gets one slot. In that space they can publish anything they damn well please. It can be an essay on the color red. It can be a case study of a paranoid schizophrenic. It can be an analysis of the architectural styles found in Port Burroughs, Mars. Our readers like the grab bag approach. They like having their horizons broadened. The eclectic nature of the subject material is worth snob points at the next social outing. They all seek to outdo one another with titillating trivia gleaned from this month's article on the sexual habits of the inigloo, a fist-sized primate that lives in Greensward. They pay a steep price for a large-format glossy magazine that still goes to the trouble and expense to publish on paper. Looks good on the coffee table, you see.

Randall Barker, one of the editors, had decided that he wanted an article on *adaman*, an exotic hardwood of great beauty and even greater price. A fair percentage of our magazines end up on coffee tables made of adaman. Each and every one of those tables cost as much as I make in six months.

Did I mention that Randall Barker has eyes for my fiancee?

Thirty-eight light-years in six days.

Not bad, I guess, especially considering that the ship was a Lockheed *Starbounder*—modern twenty years ago, moderate ten years ago, hopelessly outmoded today. But you can hardly expect Delta to put the latest ships on the backwater runs. And Messagie, my destination, was nothing if not a backwater.

Still, six days is six days, and I was already half out of my mind with a sick combination of boredom due to my enforced confinement and worry about Stephanie. I'd tried to call her—left messages, even—somehow I just never seemed to catch her at home. That was hardly surprising. By now Stephanie probably had her number in half the black books in town. Wherever she was, whatever she was doing, I could guarantee Stephanie was not bored.

I schooled myself as best I could for patience. It was only three months, I kept telling myself. I could make it for three months, couldn't I?

A nasty little voice in the back of my mind kept telling me that *I* could, but whether my relationship with Stephanie would survive . . . that was another matter entirely.

Messagie was remarkable only for two things. The first was adaman, of course. The second was the tree from which the wood came.

Totally unremarkable in the overall

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scheme of things was the fact that it's always winter on Messagie. Snow puffed into my face as I stepped stiffly down the ramp from the freight shuttle. My legs felt as though they had been splinted. I was unaccustomed to wearing so much bulky clothing and I felt like an overinflated balloon.

The man who met me was perhaps fifty, rough and weather-beaten looking. Enough character etched into the lines of his face for three men. He looked at me—not exactly disapprovingly—more as though he was taking my measure. He wasn't telegraphing his conclusions and I wasn't about to ask.

I stuck out my gloved hand. His was bare and callused and had a grip that could teach my grandfather's vise a thing or two. "My name's Michael Sokol," I told him.

"Luther Kellerman. I'm what you might call the mayor," he responded, and released my hand. He turned and started walking away from me.

My gaze, which had been on him, traveled back to the nearest tree, about a kilometer away, then up. And up. Then up some more. Then the tree faded out, obscured by the falling snow and the low cloud cover. And all I had seen so far was trunk; the limbs wouldn't start until somewhere around two thousand meters. Since the cloud cover on Messagie is pretty nearly constant, it's rare to see all the way to the top of an adaman, but I had been assured that the sight was awe inspiring. Before I left home, I had sat for quite some time staring at a diagram in the encyclopedia comparing a redwood to an adaman tree—the redwood looked like a toothpick standing next to a fat pencil. As much as thirty-five hundred meters in height and with some specimens approaching three hundred in diameter, an adaman tree is anything but your average bonsai.

The human mind, at least one raised on Earth, is not prepared for the sheer immensity of a single adaman tree, let alone an entire forest of them. I went through a few seconds of a vertiginous shrinking feeling; as Alice must have felt after following the instructions on the Drink Me bottle.

The feeling passed and I forced my eyes down. Kellerman was looking back at me, face expressionless. "You coming?"

I hefted my bag and hurried to catch up.

"You wanted to know about the trees," he prompted.

I nodded. "Biggest living things known to man. You can't help but be fascinated with something like that."

"And the wood."

"Yeah. And the wood."

"Well, that's what we do here. We mine the wood. Only thing we've got that's worth a damn, unless you know someone who wants to buy snow."

His face hadn't changed, so I didn't know if he was serious or evidencing a particularly dry sort of humor, but I grinned anyway. "Is that what you call it? Mining?"

He glanced at me. "What would you call it?"

I shrugged. Really, it was as good a word as any. The trees were far, far too large to cut down. The impact of

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one hitting the ground would probably trigger seismic activity. Instead, they cut into the living tree. No worse from the tree's point of view than a beetle boring into a pine. By the time you had tunnels and chambers within the tree, it probably *did* begin to seem a little like a mine.

Kellerman gestured back at the shuttle. "If we had all the money they made off of our wood back on Earth, we could have decent schools for our kids, maybe even a hospital."

Interesting point to slip into the article. "So all the money—"

"Middlemen," he spat. "We don't get much, here. Oh, I'll grant that freight is a tremendous part of it—the crap's heavy—but there are about eighty different layers of hands between the tree and your sawblade on Earth. Half that number would still be too many." He looked at me sideways. "How much you pay for your last piece?"

"How'd you know I was a woodworker?" It was the nominal reason I'd been picked by Randall to write the article on adaman. Hell of a hobby to land me in such a place as this.

"I can tell," he said. "How much did you pay?"

I thought back. "It was just a little piece." I described a square in the air with my hands. "It was almost three hundred."

His mouth tightened into a sardonic grin, the first expression I'd seen on his face. "Hell, I'll *give* you little dinky pieces like that. We burn 'em."

"Burn them? Just like that?"

Again the grin. "Man's gotta keep warm somehow, doesn't he?"

It made sense, but . . . it beggared my imagination to tally the worth of what a fire would burn during the course of a single evening. Even knowing intellectually that adaman would be cheap on Messagie hadn't prepared me for the simple fact that they literally had enough of it to burn. Yes, they got a lot of their heat by burning the methane given off by recycling their wastes, but to supplement that by burning adaman—clearly, I had some readjusting to do.

Somewhere deep down inside, I have a conviction that making myself come to terms with the very *differentness* of other peoples and other places will keep me from growing old. Calisthenics for the mind. I trudged through the snow next to Kellerman, doing my brain exercises. One, two . . . one, two . . . working off the mental flab.

The village was small. A double row of buildings flanked the single-lane street, reminding me incongruously of the simple, linear towns in old Westerns. The buildings stood close to one another, as though huddled together for warmth. Some were so close that only one person would have been able to walk between them at a time. All had planks bridging the space between adjacent roofs, making the entire village, in a sense, two extended buildings, one along each side of the street. The buildings were all of wood—adaman, of course—on stone foundations.

I shook my head. The price of one of these plain wooden buildings would equal that of a mansion if it were to be transported to Earth.

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Kellerman had seen me shake my head. "What? You don't like our town?" There was an edge to his voice.

All I could do was chuckle in return. "I was just thinking that, at least in Earth dollars, you live in palaces."

"I suppose so." He gestured towards a building to our left, one nearly at the end of the street. "You'll be staying with me, at least for the first week or two. Then we'll see if someone else wants to take you over for a while. We're not really set up for visitors. In fact, you're the first person to ever stay over between shuttles."

Frowning, I said, "Seems like tourism would be an obvious draw."

He snorted. "Think it through. They come, they see the trees. In six hours they're ready to go home. But the shuttle only comes in once every three months. What are they going to do for the rest of the time?"

I nodded. "Right."

He stepped up onto a broad wooden porch that ran halfway across the back of his house. Stomping his boots to get the clotted snow out of the treads, he held the door open as I slipped past into a room that served as kitchen, dining room, and living room. All the cooking implements were of metal, battered and burnished from long use. The computer terminal was obsolete to the point of being an antique.

To my right there were three doors, all standing open. The ones on either side were tiny bedrooms. The one in the middle was a bathroom. That was it. The whole house might have measured four meters by eight.

I walked over to a window on the opposite wall that looked out on the street. Triple panes to keep heat loss to a minimum, I noticed.

He said, "One thing I'd like you to do to sort of earn your keep while you're staying with me is to make sure the shutters are closed every night."

I nodded. "Be glad to. I imagine it helps keep the heat in."

Kellerman rubbed his hands together. "I think of it as keeping the cold out. You live here as long as I have and the cold starts to seem like a living thing."

The next morning I followed Kellerman to his tree—one of about a dozen being actively worked. The actual entrance into the tree was an arch perhaps three meters across and four high. From any distance at all it was invisible, lost in the rough, ropy furrows of the bark. Two heavy wooden doors were spread open and footprints in the previous night's snow indicated that we weren't the first to pass this way. I later learned that there were between six to ten men and women working in each tree.

Just inside the door was a small cubicle, like a coat-check room in a fancy club. Kellerman stopped at the counter, leaning on it with his elbow. "Ruby, this is the man from Earth who's come to write about us taking the wood out of the tree. His name is Michael Sokol."

Ruby reminded me irresistibly of a German hausfrau. Although not dressed for the part, the round, cheerful face was enough to convince me. She smiled broadly at me, then turned

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to Kellerman. "I'll take good care of him, Luther. Don't you worry."

She looked at me. "I keep the equipment back here, sell fresh blades and such. Every morning, everybody who works this tree has to check in with me—then they check out again that night. That way I know that no one is left inside when I lock up."

"Why not just leave it open?" I asked.

She shrugged. "Animals might come in during the night. The next morning, Luther, here, might get a surprise when he turned the corner. It's just easier to close the doors. That way we know that nothing of any size can get in."

Kellerman said, "Make damned sure you check in with Ruby every single time you come in here. If she's not here at this counter, you wait for her to finish lunch or whatever she's doing. I don't care if you have to wait an hour. Same thing on the way out."

"Why are you so careful about people being in the tree? Seems like it'd be a pretty safe place to spend the night."

Ruby answered, "Well, there's several things. Say a man's off working by himself and gets hurt, we might not know for a few days. This way, we start looking as soon as he doesn't check out. Happens about once or twice a year. Last time was about October, I think, so it's about time for someone else to get hurt. Just make sure that it isn't you."

I nodded solemnly.

"Then again," she continued, "sometimes it's the tree that gets them."

My mouth twitched. "What's it do—eat them?"

She shook her head, completely serious. "Nobody told you?"

"Told me what?"

She glanced at Kellerman, frowning. "You brought a man in here without—"

He grimaced. "I'm sorry, Ruby, I thought he knew. He says he's worked adaman before, so I thought—"

"*Humph!* Small consolation that would have been." She turned back to me. "Adaman sap is mildly hallucinogenic. Some other effects, as well, it seems." She gestured at the open doors. "We keep these open all day, no matter how bad the weather gets, so we can keep fresh air circulating though the tree."

Kellerman looked grim. "Accidents happen more because someone gets to seeing things and loses control of their saw than for any other reason. You don't want to stay in a dead-end tunnel any longer than you have to."

Ruby said, "Two or three hours aren't enough to do much to you, but I wouldn't stay in stagnant air for much longer than that. Take a break. Go to a window. Get yourself some fresh air. The stuff clears from your body fairly quickly. Just don't overdo it."

Now I was unsure of myself. My certainty that they were having a joke at my expense was wilting under Ruby's earnest gaze. I glanced at Kellerman. On his face, too, was the look of a man who meant what he said. But still . . .

"If adaman has some kind of vapors, why didn't I have a problem

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when I worked with it at home?"

Kellerman said, "If you have to be in the tree, here, surrounded by the stuff for several hours before it begins to affect you, a small piece like the one you messed with . . ." he shrugged. "There's just not enough to bother you."

"Why not wear a mask or something?"

"By the time you keep out the fumes, the mask gets so heavy you can't stand to wear it for long. It's just easier to get fresh air once in a while."

"But what about the importers? Surely they have a warehouse full of the stuff."

"How much they might have on hand at any one time, I couldn't say, but you can be sure that they're well ventilated."

"But your house—"

He held up a ramrod straight finger. "Ah! Once the wood is dry, it's no longer a problem. Either air or kiln-dried, it doesn't matter. The wood used to build my house—and all the others in the village—has been stored outside for at least five or six years after being cut. Quite dry, I assure you. If you go back behind Town Hall, you'll see a shed where boards are stacked, drying, so that there will always be cured wood on hand if someone needs to make repairs or if a new building is needed."

Inwardly, I was pleased. That adaman had such a quirk was just more grist for my mill. The trivia hunters would have a field day.

Kellerman led me though man-made halls, caverns, and rooms, all cut from the tree itself. The sumptuous appearance of the wood was enough to convince me that here, truly, was a residence fit for a king. The ebony floor in Henry VIII's banqueting hall at Leeds Castle was nothing compared to this. So what if it was a tree house turned inside out?

The cut surface of the wood nearer the entrance hall was deep gray, the color of the side of an old barn. Dirt and grime had covered the original glory of the wood. The color was still there; I used my pocketknife to cut off a sliver in order to expose the clean wood underneath. The newer rooms, however, were vibrant. Deep reddish-brown shot through with vibrant autumn orange swirls and black accents. I also became aware of a faint odor, almost below the threshold of smell, comprised of equal parts cinnamon and coffee, with a resinous piney undertone. A wonderful smell. I sniffed deeply, enjoying every molecule that passed through my nose . . . until a sharp glance from Kellerman reminded me that I was also dealing with something more than an aroma.

I exhaled noisily, noting that adaman was like Stephanie—beautiful, but not necessarily good for you in the long run.

As field research goes, things progressed normally enough. I spent the next two weeks talking to the men and women who worked the trees. Ruby and her counterparts in the other trees grew accustomed to seeing me come in several times a day. Asking questions was a way of life for me, and people either were helpful or taciturn, according to their tempera-

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ment. I tried my best not to annoy those who did not respond well to my inquiries.

One fellow, Lane Daltry, seemed to take an instant dislike to me. I stopped by the room he was carving out, using something like a large circular saw that could make blind cuts into a solid wall.

I stood by the door and watched, making certain that I was well out of his way. Aromatic sawdust flew out of the vent at the back of the saw.

The blade was getting dull and gummy; dark resin was building up on the sides. The longer he cut, the more the smell of the overheating motor began to override that of the adaman sawdust. Eventually thick gouts of gray-blue smoke were coming out along with the sawdust as the glaze on the blade began to burn. Daltry didn't let up. He kept pushing it.

The motor gave up the unequal battle about a hand's breadth from the end of the cut. It simply lacked the torque. He switched it off, stopped to wipe his forehead, then reached down and switched the motor on again as though it could simply resume where it left off. In the meantime, the glaze had cooled enough to harden, locking the blade into the cut as surely as if it had been glued there. The motor sucked amperage through the line, but couldn't break free. A circuit breaker tripped somewhere back at the other end of the thick power cable that snaked out past my feet and down the hallway, taking the light in the room with it.

Daltry spun on his heels, seeing me for the first time, silhouetted against the still-lit hallway. "What'd you do?" he demanded angrily.

I shrugged. "Nothing. I was just standing here watching."

He tried the switch on the saw again. "It quit working."

"I think maybe the circuit breaker blew."

That didn't suit him. He went and fumbled for the switch on the lamp in the semi-gloom, fanning his hand in front of his face as though he could part the clouds of smoke. He grumbled something under his breath when the light wouldn't come on, either. Then he straight-armed me back against the side of the door and pushed past without another word.

The impact knocked the wind out of me and my head cracked sharply against the wood. I hadn't anticipated physical assault, and I'd had my hands in my pockets. Unable to keep my balance, I fell sideways onto the hall floor, landing heavily on my side. By the time I was able to disentangle myself and sit up, Daltry was gone.

Clutching one hand to my ribs where my elbow had dug in when I fell, I staggered to my feet. I felt dizzy, and, mindful of Ruby's daily reminders about the fumes from the wood, I made my way up the hall towards a window . . . and away from Daltry.

After finding a window, simply a large, tunnel-like rectangular opening in the side of the tree, I sat on the inside lip and breathed deeply. After a few minutes I began to smell the smoke from Daltry's saw and it belatedly occurred to me that I wasn't really getting all that much fresh air if

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what was flowing past me was coming from within the tree. I painfully hefted myself up farther into the window and slid along towards the outer edge. Once there, I discovered a neatly carved depression in the bark. Slipping into it, I discovered that it made a comfortably contoured seat. Not a coincidence, I was sure.

I looked down. Big mistake. My stomach turned queasy, instantly. It was a *long* way down to the ground. Once, as a tourist in New York, I had gone up to the observation deck of the Empire State Building. Although it's been quite some time since that was the tallest building in the world, looking down from there had unnerved me enough that I had had the jitters for an hour afterwards. This, however, was easily twice that high, with no barrier of any sort between me and the ground far, far below.

I closed my eyes, took a deep, slow breath, and opened them again, looking up this time. The clouds were not far above me and it looked as though it might snow again soon. The day before, I had seen Luther accurately predict the start of a snowfall, just by observing the height of the cloud cover relative to known points on a tree. When the lowering clouds reached a certain limb, he turned to me and casually remarked that I ought to raise my hood. I thought he was teasing, but damned if the first flakes didn't drift down less than five minutes after he said that. Naturally, I made a mental note to throw that into my article.

I turned my attention to the window itself. It had been cut so that the outer end of it emerged into a furrow in the bark, which saved another meter or two of cutting since the bark stood out that much farther on either side. Where I sat it was a mere half-meter thick. Proportionate to the diameter of the trunk, the bark was as thin as the skin on an apple. But how much do you need? The tree had few known indigenous enemies, and we humans had only been around for an eye-blink in the history of the species.

According to the people I had talked to, no one had yet figured out a reliable way to tell how old the trees were, as there was no discernible ring structure. The current range of estimates went from ten thousand to half a million years. Measurements of the rate of cell growth had given the half-million-year-old figure. Yet there was another camp who cited evidence that the growth went through long-term cycles. Not exactly analogous to annual rings in trees on Earth since these seemed to happen at random intervals, but similar in effect. I had heard some say, only half jokingly, that given the age of the trees, they probably recorded entire ice ages.

The wood was the densest, hardest known to man. Ebony and lignum vitae were as balsa next to adaman. I'd pretty well taken the edge off of a carbide-tipped blade with the little piece I'd worked back on Earth. The saw blades they used here were tipped with industrial diamonds and were replaced frequently—by everyone but Daltry, it seemed. Lasers, long used for novelty carvings on Earth, had been tried, but the heavy blue-gray smoke given off by the wood when heated defeated the beam after just a

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few centimeters. Add to that the fact that the wood burned lustily if overheated and they had soon gone back to saws.

More nearly translucent than woods back home, a good piece of adaman, when finished with a hand-rubbed coat of lacquer, looked as though you could sink your hand in it up to the wrist. I had heard that the last thing John Kenney, the head of 3M, did before he left the company was to have a six-meter-long table built of adaman for the boardroom so that the board of directors could rest their elbows on elegance incarnate. When the bill came in, John Kenney went out. Shareholders won't stand for that sort of extravagance when the company is losing money.

Funny thing, though. Even though Kenney left, the table stayed.

I can't say as I'd have sold it, either.

I dreaded seeing my phone bill. Six intersystem calls back to Earth for the dubious pleasure of listening to Stephanie's recorded voice saying, "I'm sorry, but I'm busy just now. If you'll leave your name. . . ."

Yes, I could have triggered her simpersona, the program on her computer which imitated the real woman, but I've always hated those things. If I'm going to take abuse in the name of love, I'll take it face to face, thank you, not delivered by an electronic golem.

The seventh time actually paid off, in a sense. I got Stephanie. She was pushing her hair back out of her eyes. She looked stunning. "Hello?"

"Hey, it's Michael. I've been trying to get you."

"Uh, right."

That's all? Not even so much as a greeting? "Listen, is everything OK? I've been worried about you."

"Yeah, well, I was on my way out. . . . I'd already locked the door and had to get out my keys and everything and run to catch the phone. You know."

Which didn't answer my question. Suddenly the conversation seemed very awkward, very one-sided. "You're not in much. I've tried calling—"

She cut me off, her tone verging on defensive, "Yeah, well, I've been out some. Busy, you know."

"Out a lot, it seems," I said testily. Dammit, I'd sworn that I'd keep my temper if I did manage to talk to her, but I was on the verge of losing it.

"Like I said. I've been busy." She switched topics. "So, how's the story coming?" Her heart wasn't in it.

"Great. The trees are really incredible when you actually get to see them up close." Hell, now I was sounding wooden. It's hard to maintain any momentum when you're the only one who wants to talk.

"Neat. Well, listen, it's good talking to you and all that, but I don't want to run up your phone bill and I need to get going, anyway."

"Well, OK. I love you."

"Bye," she said, and hung up.

Since when had Stephanie ever worried about running up *my* phone bill? And why was she dressed to kill, headed out the door at 11:30 P.M.? I'd been sure to call late so I'd have a better chance of catching her.

Whether I liked it or not, I pretty much knew the answers.

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* * *

True to his word, Luther Kellerman kept me for about two weeks, then I found myself moving down the street to stay with Norm Sat, a man I kept having to remind myself wasn't crazy. He was sap-happy—the local term for someone who'd breathed a little too much adaman in his time. His eyes sometimes went loose in his head, seeming to see further than they should, through walls, floors . . . and me.

Whereas Kellerman's cabin had been clean and well-kept, Sat's place was a dump. Literally. Things dumped in the corner, things dumped in the chairs, things dumped in the middle of the floor. Knickknacks of every description. He was a world-class pack rat. Nothing was ever thrown away. Bits of cloth, scraps of metal, even little pieces of adaman he would bring home at the end of the day just because he liked the patterns he saw in the grain and figuring of the wood.

He had an entire collection of pieces he had found with semi-recognizable faces in them, the same way that there are people on Earth who claim to see the face of Jesus in an oddly shaped potato. Sat would smoothe a piece of wood, lacquer it, and set it on a windowsill, on the mantel, or maybe just throw it in a box with twenty or thirty others. Anywhere there was space. There was enough raw adaman wood lying about that his cabin smelled as though I was still in the tree.

Grudgingly, I had to admit that some of them really did look like faces. About a dozen or so, out of probably three or four hundred, were uncannily realistic, so much so that he had given them names.

Sometimes he talked to them. Now, *that* made me nervous.

After the third day, when he had introduced me to the wooden face he called Don for perhaps the fifth time, I said, "Norm, do you really believe that these are faces?"

A quick frown passed across his face, as though I had asked a question that was too difficult for him. "Um, well . . . after you've known them a while, they kinda grow on you."

"So how long have you been collecting them?"

He blinked, and his gaze became distant. "Oh, about two hundred . . . *Greta!* . . . have I shown you Greta?" He bounced out of his seat as though he'd sat on a tack. Scurrying over to a grease-stained cardboard box that had split open along one edge, he began pawing through it, muttering under his breath. It took him a minute, but he found the one he wanted. Back to the table he came, wiping the dust off of Greta's face with his shirtsleeve. Reverently, he placed the piece of wood in my hands. "That's Greta. I've had her a *long* time. One of the first, way back when. She came to live with me from one of the boards that went into building Dick and Sheila Moit's place. Actually, I think Silas came before Greta, but I haven't seen him around recently. He'll turn up directly, though. You can count on it. Always turns up, that one does."

Greta was, indeed, a work of art. A finely patterned sweep of black arched back, giving the impression of

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thick, wavy hair. The rest of the face seemed shadowed beneath the hair. She was looking up from underneath, a coy, intimate look, like a woman would give her lover.

I looked up at Sat, then back down at the magical piece of wood in my hands. "She's beautiful," was all I could think of to say.

He sat back, smiling proudly, as though he could take credit for having creating her. Come to think of it, there was a certain amount of truth in that. "Yup. Yup. One of the best. One of my favorites. Shuttle pilot saw her one time. Wanted to buy her of'n me. Lotta money." He shook his head in a slow, wide arc, like a child. "No way. Never. Not for sale."

I nodded slowly, turning the piece slowly back and forth in my hands, helplessly falling in love. "I can see why."

That night, as I was falling asleep, something bothered me. Something about the piece of wood he called Greta. But it had been a long day, and I was tired. Whatever it was, the problem would be there in the morning. I could worry about it then.

I was dreaming. There was a campfire. I could hear the crackle of the flames. The aromatic smoke drifted past my nose. I was . . . I was . . .

My eyes snapped open. The crackling was real. The smoke was real. Light was flickering through chinks in the rickety shutters on my bedroom window. How the smoke was getting in, I didn't know, but clearly there was a draft somewhere.

I sprang from the bed, rushing for the window. Peering out through the cracks, I could see a scene from hell. The building next to Sat's house was Town Hall, all of two meters away. The wood stockpile behind it was a blazing inferno. The rear half of Town Hall itself was in flames, which is what had woken me. Black silhouettes of men and women ran back and forth, pitching snow into the roaring flames. They might as well have saved their energy.

"Norm! *Norm!*" I shouted. "Get up!" Running out into the short hallway, I kicked his door.

He barreled out of his bedroom, wild-eyed and disheveled. "*What? What?*"

"The wood's on fire! Town Hall is burning!"

His nervous eyes darted to the window in my bedroom. Then he spun on his heels, headed for the main room, the one closest to the flames.

I left him to his curses, and ran back into my room. I hadn't unpacked much more than my toothbrush, so it took no time at all to gather my belongings. If the fire could leap the distance from the wood shed to Town Hall, it wouldn't take anything at all for Sat's place to catch.

Out Sat's front door into the street. I dropped my bag, then put my computer on top. As I straightened, turning, a gust of wind whipped the dry, powdery snow across the ground. The flames crackled greedily, sucking in fresh oxygen as they reached along the joints between the boards. Already, flames were licking at the rear corner of Sat's house.

I snatched at the first long thing I

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saw, a shovel, and began to jam at the boards covering the narrow alley, trying to knock them loose before Sat's house caught. They were nailed at both ends—had to be in order to stay in place against the wind—but it was working against me. I stopped to beat against the outside wall of the house.

"Get out here and help me! Your house is catching fire."

I thought I heard a reply, but couldn't make out the words. Just then, a man came and grabbed at my sleeve. I'd been introduced to him, but couldn't remember his name. "Come help," he yelled, pointing at the wood shed.

I shook him off. "Forget the shed—it's gone. You're wasting your time. We've got to keep the other buildings from catching fire." I went back to smashing at the boards over my head, finally knocking the first one loose. It crashed to the ground, sparks swirling down behind it. Then the wind gusted again, blowing the sparks onto me and I started dancing, trying to knock them off. When I was sure that I wasn't on fire, I went at the second board. It came easily. The third wouldn't let go and the flames burning Town Hall were driving me back.

Now the rear corner of Sat's house was burning briskly. I backed out into the town's central street and reentered Sat's house through the front door. He had the lights on and was grubbing in a box for something.

"Norm, your house is burning. You've got to get out."

"Can't find Silas!"

"Norm, come on, it's too late! You've got to get out now, while there's time. These houses are going up like tinderboxes."

"Gotta find Silas, dammit! Can't leave him here, he'll burn."

"You idiot, *you'll* burn if you stay. Now, come *on!*"

He pointed at a cardboard box by my feet, full of his adaman faces. I could see Greta on top. "Take that out. I'll be there in a minute."

Folly is humankind's middle name. I shook my head, grabbed the box, and ran for the door. As my foot hit the second step, a giant hand slapped me in the back, driving me face forward into the snow. An enormous concussion squeezed my body from all directions at once.

Norm Sat's house had exploded.

Rolling over, coughing raggedly, I staggered to my feet. There was no thought of rushing in to save him. The entire rear half of the house was demolished. The front door had blown off its hinges and I could see straight through the roiling flames into the forest behind.

Seizing the box, I dragged it back away from the flames, next to my bag and computer. I collapsed next to that small pile of belongings and held my head. My ears were ringing so loudly that I couldn't hear anything when someone ran up and started yelling at me.

"I can't hear," I bellowed, or thought I did. I couldn't even hear myself. When I brought my hands down from my head, my right was bloody, whether from a cut or a bleeding eardrum, I had no idea.

The silhouette jerked at me. This time, I got the message. They wanted me on my feet. Groggily, I pushed my-

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self into a standing position. Hands started tugging me away. I fought back long enough to lean down and pick up my bag, my computer, and Sat's box, then allowed them to lead me away.

No sooner had we turned than Town Hall blew, in much the same manner as Sat's house. Finally, it dawned on me—the methane tanks were exploding.

When the house on the other side of Town Hall went off with a blast even I could hear clearly, I started running. I turned to make sure my companion was still with me.

The face within the hood was that of a young woman, her face lit by the raging flames. Tears streaked smudged cheeks below staring, horrified eyes. We made it to the end of the street, just past the last of the houses. Others were there with pathetic piles of whatever they had been able to grab quickly. My guide let go of me and turned back towards the flames. Before she had taken three steps, the house this side of Sat's went, hurling a seething ball of tormented flame towards the sky.

Something deep within me rebelled at letting a woman go back into a self-destructing village in search of survivors while I stood rooted in the snow like a fence post. I dropped my belongings and started after her.

I caught up and tried to communicate by gestures that I was going to help her. She either didn't understand what I was trying to get across or was shell-shocked and just didn't care. I staggered up to the first door and, without bothering to knock, jerked it open and entered. They were already coming out. I reached out my arms, offering to carry something . . . anything. I ended up with a child, perhaps two years old. I turned to go, but something made me duck into a door on the left, guessing correctly that it was a bedroom, and, holding the child cradled in my left arm, I swept the blankets and covers from the bed with my right. No matter what else happened, the kid would need to be kept warm.

After depositing the child and its mother at the end of the street, the father and I went back. I caught a look at his face by firelight. Charlie Elmore. He worked a different tree from either Kellerman or Sat, so I knew little about him. Now I knew him to be a married man, a father, and barring a miracle, one soon to be homeless.

While he made another run with clothes and more blankets, I went to the next house. No one there. Hopefully they were already out. The next house was already smoldering as I mounted the steps. Just as I reached for the door, Ruby came bustling out as though all the hounds of hell were on her heels. She ran straight into my chest, then backed up, clearly surprised to find someone in her way.

"Anything I can carry?" I shouted. I could almost hear myself. Perhaps I wasn't permanently deafened, after all.

She shook her head, then changed her mind. Taking me by the hand, she led me back into the house. I couldn't quite hear her words, but her gestures told me what I needed to know. There was a shelf above the sink with

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china on it. With no time to be delicate, I hurriedly stacked the plates in descending order of size, then balanced as many teacups as I could on top. She grabbed one more and stuck it in a capacious pocket in her wrap, and away we went, down to the end of the street. We managed another trip and got the rest, plus her silver. Then her house was gone.

It became a routine. I worked just ahead of the flames, helping people gather as many belongings as we could save. The end of the street began to resemble a rummage sale. At some point, I realized that I was working the other side of the street. Somehow the fire had jumped over to the other row of houses. I hadn't really noticed. I had just taken for granted that they were all in danger of burning.

The heat from the fires had melted the snow in the street, turning it into a quagmire. I was wet and muddy, hot one moment while near the flames, freezing the next while at the end of the street depositing an armload of salvaged clothing.

I stopped when there were no more houses to be emptied—no more people to be pulled to safety. By degrees my hearing was returning, although I still had a ferocious ringing in my ears. The crying of the children was heartrending because there was nothing I could do to ease their anguish. I stood like a robot with its power cut off, another balled up wad of blankets in my arms, facing a small crowd of devastated people. I was waiting for someone to take the covers from me, but no one seemed interested. They were all looking past me.

I turned. There, smoking in the dim gray light of dawn, was what remained of the village. There was damned little of it. The adaman had burned with a will, and all that was left of most of the houses was the rough stone foundations. Smoke curled insolently from the ruins, as though to cruelly emphasize the totality of the loss. Not a single building stood.

I stood transfixed, like the rest of them, until the first flakes of snow began to fall. Then it hit me that they would need shelter and food. The weather on Messagie would not wait until it was convenient.

I simply dropped the blankets on the ground and turned, scanning the faces for Kellerman.

"Luther!" I called. "We've got to get these people in out of the snow. Can we use your tree?"

"But the fumes—" he began.

I shook my head. "We don't have a choice, Luther. There are children out here. We've got to get them out of the wind."

There was nothing he could say to that. He nodded, accepting that it was the lesser of two evils, and picked up some things at his feet. I picked the blankets back up and trudged off towards the tree. Halfway there, I became aware that someone was walking beside me. I glanced, seeing that it was the woman who had come for me after Sat's house had exploded. I didn't know her name.

"Thanks," she said.

I took a deep breath, then let it out, as much a sigh as anything else. "It was just something that needed doing."

"You didn't have to. You don't live

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here. You didn't have anything to lose."

"Actually, I did."

She glanced up at me.

"My self-respect."

Ruby threw open the doors to the tree, started the ventilation fans, then went back for another load. It took a little over an hour to get everything from the end of the street into the tree.

There was one more thing I needed to do before I could allow myself rest. Once again, I sought out Kellerman.

"Food," I said. "We're going to need—"

He held up his hand, nodding, having anticipated me. "Already working on it. We're not in any immediate danger there. We have a building that sat away from town where we cured meat. I've sent someone to get some."

"Away from town?"

"Can't have predators sniffing about when they smell meat, can we?"

I nodded. "OK. If you need me, let me know. I'm going to rest for a few minutes."

He nodded, reaching out to grip my shoulder. "You earned it."

I went, found my bag, and collapsed against it, using it for a pillow.

Careful fingers were probing the side of my face and it hurt like hell. I pried open my eyes—I hadn't realized that I had fallen asleep—to find that Ruby was dabbing at the side of my head with a blood-stained rag.

My best attempt at a grin felt lopsided. "You've got a lot of people to check into your tree today, ma'am," I told her.

She smiled sadly. "There's a few who won't be here."

It took a moment for me to catch her meaning. "How many?"

She wrung the rag out into a small bowl of water—part of her china set, I realized. "Eight, we think. It's hard to do a head count under the circumstances, but Luther is working on it."

I winced as she resumed dabbing at the side of my face.

"You've got a nasty cut here," she said, by way of explanation.

"I was afraid it was my ear. When Sat's house went up it pretty much did in my hearing for a while, but it seems to be coming back."

She nodded. "Kirdre was worried about you."

"Who?"

"You were talking to her earlier, on the way to the tree."

I nodded. "I'm sorry. I didn't know her name."

Ruby added, "Your hand is hurt, too. You might want to take it easy for a bit."

I frowned, lifting my hands for inspection. My left hand was wrapped in a clean, white rag, probably torn from a sheet. I had known about my head, but for the life of me, I couldn't remember hurting my hand. I looked back up at her. "Now what?"

"What do you mean?"

"Well, we've got to start thinking about building shelter, something that won't burn this time. Stone, probably. I know it sounds callous, but we've also got to get you people back into production. Rebuilding is going to cost money, and—"

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"And we don't have any," she finished for me.

I nodded. "Nails, wire, blankets . . ."

"I see where you're going." She stopped dabbing at the side of my head. "All I can think about is getting through today. Tomorrow will have to take care of itself."

"Ruby, we can't wait too long."

"We?"

"What?"

"You said *we* can't wait too long. *You* aren't under any obligation to help. Next time the shuttle comes in, you're going home."

For some reason, that brought to mind Stephanie's impatience to get out the door. I sighed. "In my absence, I imagine that my house has burned, as well."

She didn't understand what I meant, of course, so I gave her a rough sketch of the situation back home. She didn't say anything when I was done—just looked at me. What she was thinking, I couldn't tell. She laid her hand on mine, my good one, for a moment, then moved on to her next patient.

Early the next morning I walked down to the village. It's not as though I could accomplish anything, but I felt drawn to the ruins.

Another set of footprints preceded me through the fresh snow. Smallish footprints. For some reason, I expected to see Ruby when I got to the village, but it was Kirdre whose form materialized out of the drifting snow.

"Be careful," she said, "it's slick."

Indeed, the snow that had melted in the street during the fire had refrozen into a solid sheet of muddy ice streaked with ebony soot. In most places the surface was rough enough to provide decent traction, but in some the water had pooled before freezing and the resulting surface was as smooth and treacherous as a patch of oil.

We walked slowly among the remains of the houses, side by side. She stopped. "This was mine," she said simply.

"I'm sorry." What else do you say to someone who has lost everything but the clothes on her back?

She stepped carefully over the low stone foundation wall. I followed. The intense heat had caused some of the rocks to spall off cupped pieces that reminded me of discarded, broken eggshells. "My room was here." She walked a little farther. "The kitchen was here." A few steps more and she whispered something too softly for me to hear. She turned, I opened my arms, and she fell against my chest, sobbing.

Guilt came to me, unbidden. I shouldn't be holding this woman. Stephanie was waiting for me to return to Miami, and my arms were only for her.

But were Stephanie's arms only for me?

I sighed and held Kirdre closer.

Eventually, we made our way to where Town Hall had stood. Along the side wall steel filing cabinets lay jumbled after falling through the floor when it collapsed. The paint was blackened and blistered, and in places the raw metal showed through, already revealing a light brown patina

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of rust. The exterior walls had fallen outwards and the roof had followed the opposite side wall on the way down so the heat had not been as intense or prolonged here. That and the lack of sufficient air inside the cabinets had largely spared the contents.

I heaved one upright and opened the top drawer. The paper files were yellowed and brittle, lightly toasted along the edges, but still legible. I pulled open the second drawer and saw that it contained what appeared to be birth certificates and medical records. I called Kirdre over. Gesturing at them, I said, "These might help Luther determine . . ." My voice trailed off as my eye caught something. Curtis Andersson, a fellow I had interviewed late the previous week, born . . . *when?*

Must have been his father.

Then I realized there was no date of death. Frowning, I flipped to the one behind it. I didn't recognize the name. The dates indicated that she had died at age seven. The one behind that was another name I didn't recognize, but if the dates were to be believed . . . let's see, eight minus three, carry one to subtract four from one . . . no way. I adopted a different tactic, flipping through until I found Luther Kellerman.

I stood stock still, staring at that page for three seconds less than forever. Luther Kellerman was 171 years old.

I looked at Kirdre, confused. She was standing very close to me. "What's your last name?" I asked.

"Pye," she said in a small voice.

My gloved fingers were clumsy at migrating through the files, but I found it. I closed my eyes and took a deep breath before turning to face her. "Kirdre—"

Her eyes refused to meet mine. "It was too soon to talk about it."

"Too soon to talk about *what?*"

"I . . ." she turned her head away sharply, as though she didn't want me to see her face. "It wasn't supposed to come up this way. We need you here. I had it in mind to . . . oh, hell."

I gently took her chin and pulled her face around towards mine. "Talk to me. What's going on around here?"

"It's the trees."

"It's the trees?" I repeated, blinking.

"Something about the trees. We think it's the fumes from the wood, but we don't know. We don't have a research laboratory. We can't afford one. We can't ask for a research team from Earth without telling them why. We can't have people storming in here in search of the fountain of youth because . . ." she paused, searching my face, "one way or another, it kills most of them."

"It—"

She gestured at the open drawer at my elbow. "Susaen Andreeth was my best friend's daughter. We think it's genetic—a recessive trait—she didn't have it. If you don't have it, it drives you the other way. You get old fast. Days are weeks. Months are years. Years are entire decades. She died of old age at seven, wanting to play hopscotch one last time. She couldn't. Her body was sagging . . . old." Kirdre looked away from me again, but the words came in a rush. "Lane Daltry caught her when she was about

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three—looked like she was in her twenties—fortunately there weren't any children. She never really understood what was happening, only that it felt good."

Too much, too much. I couldn't assimilate the things she was telling me. And to make matters worse, I suddenly remembered what I had been thinking just before I went to sleep in Sat's house. Something about Greta. He had started to say that he had found her almost two hundred, and in my mind I filled in the blank . . . *years* ago.

She continued, "Of those who survive the physical aspects, some can't handle the mental strain. There's not a lot to do on Messagie, and some people get, well, bored. We have a statistically high percentage of suicides."

A high price to pay. It was easy to see why they wanted to keep it quiet. "So once you find out that you're going to live, then—"

"Why do you think we have silly little make-work jobs like Ruby's? So she can breathe the tree. Why don't the cutters wear masks to keep out the fumes? They need it, too. If you leave, then you live and die just like anyone else."

"Too much and you end up like Sat. Too little and you live a normal life span."

She nodded. "Something like that."

"So how long do you live?"

A wry smile. "Well, whatever's in that stuff, it clearly works pretty well for the trees. We've not yet really had anyone die of old age. They just get stranger and stranger, like Norm. Sooner or later, he would have had an accident with his saw, I guess."

I shook my head slowly. No one part of it was all that strange, and in retrospect, they hadn't even been hiding it all that carefully. The hints were everywhere. "So you're asking me to stay, is that it? Add some diversity to the gene pool. I've survived several weeks without aging, so I must have this gene."

"I know that the way I've told you these things makes it sound terrible. But we're here, and you saw the files, and I couldn't think of a way to just toss it off."

Gently, I brushed the snowflakes from her hair. "Helluva way to spend the morning."

"Ruby said that your, um, personal life isn't all that wonderful right now."

Involuntarily, my mouth tightened. Well, it wasn't as though I had asked Ruby to keep it a secret. "No, it isn't," I admitted.

She smiled shyly and held out her hand. "Let's start over. Hi, my name's Kirdre."

I reached out and took her hand. "I'm Michael, and this is all going way too fast, but it seems that I've got a decision to make. Maybe you could help."

Hand in hand, we stepped over the remains of the foundation of the building that had been Town Hall and walked into the forest. And talked. I talked to her as I have rarely talked to anyone, man or woman, in my entire life. I talked to her the way I'd been trying to talk to Stephanie for the last two years. But whereas Stephanie had given sullen silences in return, Kirdre weighed the things I said, turned them over, and showed me different

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perspectives. Insight, she had, and wisdom. Perhaps it was her age. On the other hand, maybe she was just that kind of woman.

One thing she was not, was jaded. Everything was interesting to her. She would stop, lightly touch the bark of one of the trees we passed, tell me some small bit of wood lore, then resume exactly where she had left off.

During that walk with Kirdre, I discovered something . . . mostly about myself.

Stephanie's beauty was a cultural product, bought in bottles, applied staring into mirrors. With it, she was an astonishingly desirable creature. Without it, she was plain, a blank canvas. Her personality was another null. She had certain artifices, but, like her makeup, they were only superficial appliqués. I realized that perhaps the reason she didn't talk to me was that she couldn't. There wasn't anything to say, because there was no person underneath the bright smiles and sparkling eyes.

Kirdre, by comparison, was substantial and whole. While not overtly beautiful, although she did have lovely eyes, there was a person inside, and that lit her up from within. No makeup, no mirrors. All natural. Genuine.

Hours passed. We walked. We talked. It was a seduction of sorts, pure and simple. Kirdre wanted to show me the good side of Messagie. I'd seen some of the bad parts. She showed me the snow-dappled forest, with its cathedral-like velvety quiet that made a perfect background for thinking. In contrast with the background noise level in the city I had left, the silence was nearly deafening. She showed me the beauty of the trees. I had taken for granted the wood itself. Kirdre introduced me to the trees themselves, the snowflakes that drifted into crevices in the bark, the wholesome smell of the air that sighed between the gargantuan trunks.

Always, I had felt an amused contempt for musicians and other assorted lost souls who went into the Himalayas to find a guru and meditate. What could they find there that they could not find at home? Belatedly, I began to see that there might possibly be something to their pilgrimages.

Perhaps it was time to begin my own.

Luther and I sat across from each other at the table. Kirdre sat beside me. Ruby sat beside him. I had a plan. He was skeptical.

"Luther, you've *got* to bring more people in. With as few people as you have now, you'll never manage much more than a subsistence economy. You, yourself told me that you need better schooling for your children, a hospital—"

"But what will we do when so many of them *die?*" he demanded. "We can't just go killing off ninety-nine out of a hundred immigrants. That's bound to become unpopular, fast."

"Let's say that enough people came in to make up a decent-sized town. A lot of the suicides are due to the monotony, the boredom. If they had enough people to associate with, then they would feel less isolated. As for the tree killing them, surely some-

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one can identify the trait that they would need to have in order to survive. If you filter out the ones who are at risk, then you're not killing them off, right? Hell, with a little genetic work, they can probably fix the problem."

"Still . . ." he grumbled.

"There's no reason Messagie should not become more self-sufficient. You're importing all your tools. That's expensive. Find some ore. Start an iron mine. Make steel from the iron. Make saw blades from the steel. Cut adaman with the saw blades and make furniture from the adaman. Which reminds me . . . you've got to start sending out finished goods in addition to the raw lumber. You're throwing away profit. Hell, that would provide employment for some of the immigrants right there."

Luther's eyes were narrowed, his mouth drawn. "And just how do you expect to get all this started?"

"I know the shed burned, but is there any cured wood left?"

"Some. 'Bout enough to build a house, I reckon. We tried something a few years back. Someone, Norm, in fact, wanted to try curing wood inside the tree. He had some damn fool idea that the color would be better if it cured out inside the tree. Last time I looked, it was about like all the rest, so I don't think his idea was worth diddly. Also, we tried kiln drying the wood once upon a time. Now that definitely is *not* as good as air drying, but it's a hell of a lot faster. Anyway, there's some wood, and I can get you more."

I nodded. "Good. Start with coffee tables and end tables, built so they'll nest inside one another in order not to take up any more room than necessary. Then fill in any remaining spaces with candlestick holders, coasters, jewelry boxes, anything that will fit. That stuff brings a king's ransom on Earth. If we can structure things such that any significant portion of the profit comes here, then you'll be living a hell of a lot better than you are now."

Ruby nodded. "Get in some concrete and build houses that won't burn."

"If someone would go out and look, I'll bet we could find some limestone and make our own mortar. It's not that hard to make. All you need is heat. Surely, we can do it here and save that money for something else."

Luther wasn't convinced yet, but Ruby was nodding. "I think he's got something."

"*Hmmmph!*" Luther grunted at her. "Lotsa fancy talk, but I'm not sure I want somebody from Earth telling me how to do things. Where the hell is he going to be when it's time to get our hands dirty?"

"Right here," I told him, tapping the tabletop with my fingertip.

And I meant it.

So what did Stephanie think of my decision?

I went back to Earth temporarily to set up a business to receive the adaman lumber and finished goods. That cut out nearly all of the middlemen Luther had been complaining about, so a great deal more money came in afterwards.

The finished goods were an instant hit. I placed an ad where it would do

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the most good—in *Traveler of Worlds*. Perfect targeting of our prospective customer base. We charged about ten percent less than the old distributors and made a killing since we had much, much less overhead.

Randall Barker had a decidedly strange look on his face when I handed in the story, my resignation, and the ad copy, all at the same time.

Stephanie, I swear, was hurt by my abrupt declaration that our relationship was over. Not that she would miss me. As I had suspected, she and Randall had started a mutual self-destruct society before I was past Lunar orbit. Her despair, I think, was due to the fact that I took the initiative, depriving her of the opportunity to jerk the rug out from under me. I think it was a first for her to have a man leave her. She was accustomed to leaving them instead.

I suppose it goes without saying that Kirdre and I set up housekeeping. What the odds were, I couldn't say, but we had a bright-eyed baby boy who lived. Normal nine months pregnancy. I guess the placenta filters out whatever comes from the tree so as not to slow down the fetus's growth. We plan to keep him away from daily contact with the tree until he's in his teens, at least—God knows we don't want the terrible twos to last for ten years. After that, he's free to make up his own mind about when to start slowing down his aging process.

All in all, I think coming to Messagie was a good thing. It hasn't been without its trials, but my life is so much better than it was on Earth. I have peace and quiet. I can build things; I'm in charge of the woodworking shop. And, of course, I've got my family.

You know, I've gotten so that I don't even mind the cold. Not with Kirdre to keep me warm. ■

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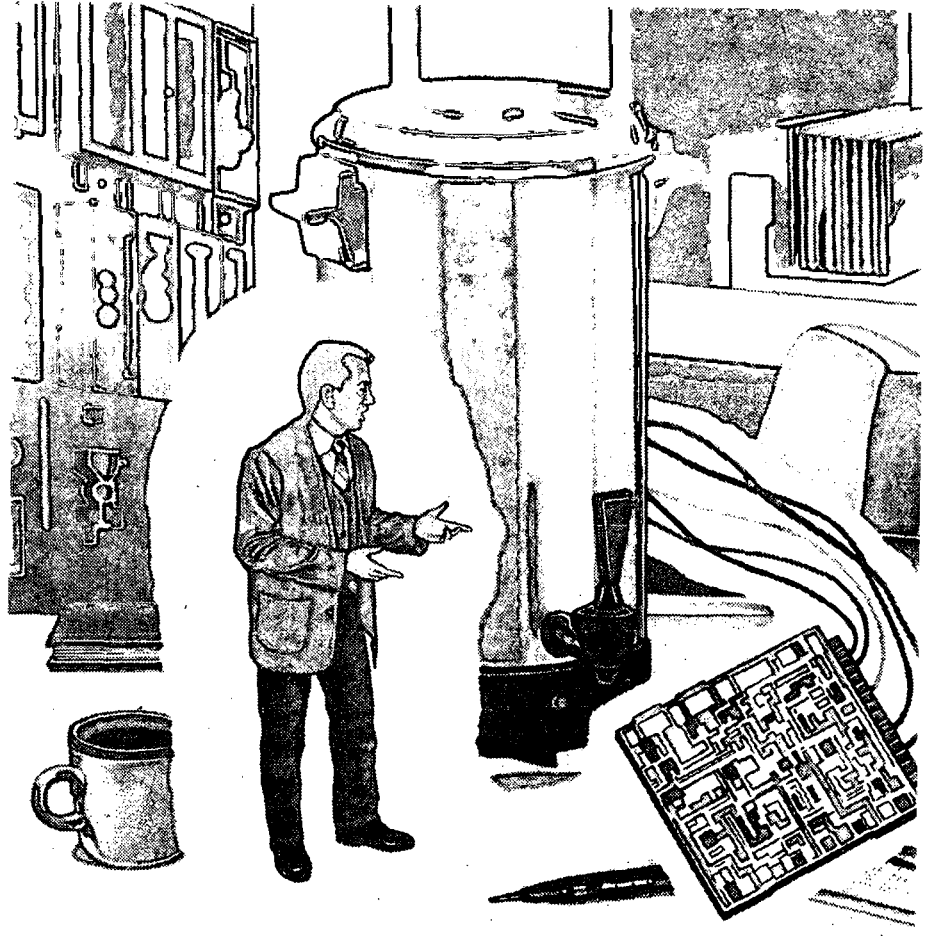

Rick Cook & Peter L. Manly

On the Application of Quantum Probability Tunneling to Improve Manufacturability of Printed Circuit Board Designs: A Case Study

Illustrated by Ron Chironna

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(Tape recording of interview between Jason Payne and his attorney, Lawrence Fisk, at Federal Jail)

"Yeah, OK, I guess. But Larry, you gotta get me out of here."

(Unintelligible)

"Dammit, I *did* cooperate. I told them the truth, just like you said, to get immunity. Yes, the *whole* truth. No, OK you're right. It's just that if that damn Sanchez hadn't come in to get a cup of coffee. . . .

"No, I guess it doesn't make a lot of sense. OK, let me go back over the whole thing, just like I told it to them."

The coffee was a real sore point with us. Some Cost Containment Weenie had noticed the printed circuit board shop used more coffee than the average department and slapped a ceiling on our supply. It did no good at all to point out that we were as far as hell and gone from the cafeteria and we worked all kinds of weird hours. All that got us was a form letter spouting the Cost Containment Credo for Effective Engineering. I was damn glad none of us had digestive problems. If we had, the Cost Containment Weenies probably would have rationed our toilet paper—not to mention flushes.

"I hear over in the main cafeteria they've got an espresso bar for afternoon coffee break," Sanchez said that afternoon when we broke for coffee.

Wilson finished the last of the stuff in his cup and ambled over to the beat-up old urn in the corner of the board shop. "Jeez," he said as he pulled the handle. "I wish this thing could make espresso." Then he looked down at his cup and his eyes bugged out.

We didn't have to ask why. From clear across the room we could smell the sharp, rich aroma of espresso wafting out of his cup.

"What did you guys do to this thing?" he demanded.

"Nothing," Sanchez protested. "We fixed the heating element like I said."

Wilson raised the cup to his lips and took an experimental sip. "You sure you didn't load it up with espresso or something? 'Cause this sure tastes like espresso to me."

I couldn't stand it any longer. I went over, got my cup off the rack and stuck it under the spout. What came splashing into my cup was weak, brown, and by no stretch of the imagination espresso.

I looked at Wilson and Wilson looked at me. "Don't ask me," he said, "all I did was pour out the coffee. Here." He pulled another mug off the drain board and tried again. This time he got the same brown junk that usually passed for coffee.

"Maybe you gotta ask it nice," Sanchez said.

I don't know why I did it. I mean to this day I really don't. But I dumped the stuff out of my cup, stuck it back under the spout, said "espresso please" and pulled.

The liquid that filled the cup sure looked like espresso. It smelled like it too when I raised the cup to my nose. And it tasted like it as it burned its way down my gullet.

"Let me try that," Sanchez said, grabbing his cup off the drain board.

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But Sanchez, he can't do anything straight. He puts his cup under the spigot and says "café latte."

And the thing hisses and spits and he gets café latte.

So there are the three of us, standing around the coffee urn, looking at each other and everyone's eyes are bigger than his neighbors'.

"Shit," says Sanchez at last. "A magic coffee urn. We got us a magic coffee urn."

For once the little bastard wasn't exaggerating.

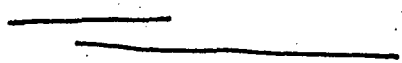
If we'd had any sense we would have left it there. We would have kept our mouths shut and we would have drunk our coffee and that would have been the end of it. But we were engineers and we couldn't leave it there. I mean we just *couldn't*. We had this unexplained phenomenon and we had to mess with it until we found out what was causing it—and what else it was good for.

The obvious place to start was the repairs to the urn. A couple of days before the thermostat had gone out on it and we'd haywired a fix with a piece of old circuit board from the scrap bin. It hadn't even been a working board, just something we'd thrown together with a lot of microwave elements on it and some more-or-less random scribbles. See, we'd been having trouble with the line widths on some of this high-frequency stuff and . . .

Oh, yeah. Well anyway we had this funny-looking printed circuit board wired into a standard coffee urn. So we stuck meters and probes and capacitance checkers and all sorts of stuff on that board. The readings we got didn't make much sense; I mean the damn thing was covered with doodles, but we kept at it.

We tried stealing the coffee urn from Drafting down the hall and cannibalizing it to repair ours. That produced the usual swamp water for coffee, no matter what we asked for. Then we took off the unit we'd cannibalized and put the PC board back in place and we got whatever kind of coffee we asked for. (Except Irish. Sanchez couldn't get it to add whiskey.) We snuck the other urn back into Drafting and settled down to try to make sense out of that damn PC board.

That was especially tricky because at microwave frequencies things go funny and the leads themselves become part of the active circuit elements. So (sound of chair scraping) you put something like this on the board:



(fig 1, recovered from wastebasket in interview room)

and that's a capacitor. This:

(fig 2 recovered from wastebasket in interview room.)

is a transformer. And so on.

No, listen, dammit, this *is* important. It's the key to the whole thing.

Anyhow, what was on that board

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was one part standard microwave components from the CAD library placed sort of at random and strung together any which way, and one part just doodles. But it did something.

And we couldn't duplicate it. I mean not at first. We copied the doodles and the components exactly and it didn't do anything.

Then Wilson came up with this crazy idea. Have you met Wilson's wife? His second one, Sherri, the one with the little tiny voice and the great big . . . anyway, she's really into all this New Age crap.

So here we are sitting around, staring at that damn board and drinking our gourmet coffee. (Mine was Kenyan, the kind with the smoky taste that goes for $25 a pound when you can get it.) Then Wilson sets down his mug and squints sorta sideways at the board.

"You know," he says slowly, "if I didn't know better I'd swear some of that stuff looks like pictures in a book Sherri's got, a grimoire."

Well, what the hell? Anything's worth a try. Besides, screwing with that damn coffee maker kept us sane while we wrestled with our *real* problem. The, ah, Mighty Fine Board—TMFB for short.

If the coffee was a sore point, TMFB was acute appendicitis, kidney stones, and third-degree hemorrhoids. Some bright, young, freshly minted engineer over in Circuit Design had figured out that you could save a bundle on parts and production costs if you minimized the number of passive components on this particular board. So he cranked up his shiny new software and turned out a design that did away with maybe a third of those resistors, capacitors and such. Of course management loved him for such a shining example of Effective Engineering through Cost Containment. (Supposedly pronounced "eekks." In our shop it sounded more like a fart.)

Unfortunately the bright, young, etc. was so green he believed what the software told him. The result was that the circuit was manufacturable, but would only work right if the tolerances stacked just so. Which meant that a lot of the time it didn't work at all, and the board shop caught the flak because our implementation was supposed to make up for the missing components.

We kept revising the thing, throwing it over the wall to Manufacturing and they kept throwing it right back to us for "excessive defects in implementation" or some such crap. We couldn't buck the blame back up where it belonged because the designer was a hero and he could show the suits where his shiny new software said it worked. So we were the ground between a rock and a hard place and about all we could do was keep making useless fiddles on the implementation and distracting ourselves with the damn coffee maker.

Yes, Larry, that's important too. Just let me finish.

So the next day, Wilson brings in his wife's grimoire. Its title is *Ye Fecretf Of Antient And Forgotten Wifdom* and it's a $19.95 paperback full of old woodcuts. Some of these things, sigils and talismans and stuff actually look kinda like microwave

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components on a printed circuit board—only you'll go blind if you try to figure out what they'd do.

So we just started slapping stuff on boards, running them through our prototyper and putting power to them to see what happened. Eventually we got—well, we thought we got—lucky.

It wasn't as simple as that. We finally figured out that what we were looking at was a four-layer design. It also turned out the line widths varied in important ways and the spacing was a little different than what it showed in the book. And of course we were completely in the dark about what frequency to operate it at. But we kept at it. We got showers of green sparks. We got blue flashes. We got clouds of stinking orange smoke. We got a board that melted into a puddle and another one that flapped around like a fish as soon as we applied power. But we kept getting closer and closer until finally we got something that produced a blue haze over the board as soon as we fed it power. I held my breath and Sanchez fiddled with the frequency generator and all of a sudden there was a blinding blue flash on the bench and there *be* was.

My first thought was someone had painted a Ken doll blue and dressed him in a three-piece suit. Then I realized his skin was kind of scaly under the blue and when he moved his head to look around, well . . .

"Good afternoon, gentlemen," he said in a voice that was a little high but otherwise normal. We all just stared and he cocked his head and raised an eyebrow, like he was waiting for us to say something.

"We, ah, we don't see many demons around here." It was inane but it was the best thing I could think of.

"And with this kind of transport you're not going to see many more," the little thing said, brushing itself off. "And I'm an IMP, not a DEMON."

"Imp?" Wilson said, just to get his jaw to close.

"Interdimensional Manufacturing Partners. DEMON is one of our competitors."

We all nodded like we understood.

"You can call me Mr. Smith," the thing said. "Now gentlemen, suppose you tell me about your problem?"

"How do you know we have a problem?" Wilson asked.

The imp grimaced. "People like you *always* have a problem," he said. "That's why you summon probability engineering consultants like IMP. So what's your problem?"

He looked at us, we looked at him, and the silence stretched on.

"Well, we've got this coffee maker—" Wilson finally begin.

"With modifications, I see. But offhand I don't see the problem with it. It isn't broken, is it?"

"It keeps giving us fancy coffees."

"Can you remove the modification?"

"Well, yeah," Wilson said slowly. "But we like the fancy coffees."

"Then leave the modification," Mr. Smith said with a wave of his tiny hand.

"There's this circuit board," Sanchez picked one up off the bench. The little creature hefted it in both hands and swiveled his head as he scanned over the surface, frowning as he did.

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"Yes, this definitely presents a problem in probability engineering. Fortunately the group I represent has an experienced and efficient probability engineering staff that is well equipped to handle your needs."

Wilson finished his espresso in one gullet-searing gulp. "You mean you can make this damn thing work?"

"Of course." The imp looked slightly offended.

It sounded too good to be true. But hell, there was a time when a transistor sounded too good to be true. The quantum mechanical explanation for a modern transistor was weird enough, why not something like quantum engineering for probability?

Yeah Larry, we were really desperate.

So over the next couple of hours we talked price with a little blue man standing on the workbench. Smith was sharp, but Wilson and I had been around the block a few times and we caught the stuff—most of the stuff—he tried to slip by us. Finally, around quitting time we had a provisional contract between DynoDyne Aerospace and IMP Consultants.

"We don't have to sign in blood or anything, do we?" Sanchez asked very seriously as we came to the end.

"Only if you want to," the imp said.

No one wanted to, so we signed the thing in non-repro blue felt-tip, since that's what Wilson happened to have in his shirt pocket.

Well, the board shop had some contracting authority. So by splitting the deal up into several pieces and hiding it under misleading names and other finagling we were able to cover it.

There was a little trouble about their first invoice. Seems accounts payable wasn't used to getting invoices on parchment, and the letters of golden fire played hell with their optical scanner. But we were able to get all that straightened out without too much trouble.

So a couple of days later I'm sweating over the umpty-umpth revision of TMFB when the phone rings.

"This is the guard in the main lobby. There are two wombats and a koala here to see you."

"Two wombats and a koala," I repeated.

"Well sir, they say they're wombats." The guard's voice was carefully neutral. "And the other one sure looks like a koala."

The silence stretched on. "They say they're here for a contract job."

"*Oh!* Uh, right. I'll be right out. Make them comfortable, will you?"

Sure enough they were waiting for me when I arrived, sitting on one of the sofas in the lobby side by side like someone's collection of stuffed toys. Only the fact that the smaller wombat was chewing meditatively on a branch from one of the lobby's ficus trees showed they were alive. The two salesmen who were also sitting in the lobby were working very hard at not noticing and the guard was watching them out of the corner of his eye. I noticed he had his holster strap unsnapped.

"Jack," the larger wombat said as I approached. "These are my mates Digger and Clancy." He glared at the smaller wombat who dropped the ficus branch and blushed. At least I think he blushed, I mean how do you tell with all that fur on a wombat?

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"I wasn't expecting you to look, uh, like this," I said as soon as we were out of earshot of the lobby.

"Figured it was best if we looked like the natives, right?"

"But wombats and koalas live in Australia."

The wombat looked around. "And this isn't Australia?"

"Different continent. Besides, they're not intelligent."

The wombat muttered something under his breath about "bloody research department" and then shrugged. "S'all right mate. We're used to cockups in this business. After all, it's the job that counts, isn't it? So let's get on with it."

No, I don't really know what they did, but they did something. All of a sudden stuff started to *work*, and not just the coffee urn. For the first time in living memory the plotter would produce three drawings in a row without shredding one. The etch bath temperature stabilized and the manufacturer's specs actually worked. And all the while there's this gang of refugees from an Australian zoo over in the corner, obviously working away at I-don't-know-what.

At first we didn't know what to make of it. I mean suddenly our work load was cut maybe by two-thirds. We started working eight-hour days. No more weekends. And we were actually filling out our schedule sheets honestly! It was amazing.

Oh, there was the usual quota of corporate BS to deal with. The company started a new quality drive. We got a couple of visits from inspection teams looking for safety violations. Our consultants pretended to be stuffed animals and we explained them as gifts for Sanchez's nieces, but that was the closest we had to a problem.

So there we were, sailing along. The latest revision of TMFB was working fine, all our projects were on schedule for a change and most of them were under budget. Life was good.

I should have been scared to death.

I didn't really begin to figure it out until Dark Gray Tuesday, the day before Black Wednesday, the Night Eagle's scheduled rollout.

You know about the Night Eagle, the super-stealthy unmanned recon aircraft that was going to save the company from the merger mania that had hit the defense industry after the Cold War. It was hot. It was new, it was sexy, it was wicked looking and it was going to keep the company afloat into the next century. The Night Eagle program was probably the only thing corporate management took more seriously than CCTEE. Cost Containment Through Effective Engineering was a fad. This was *business*.

The big day was Wednesday and the company had pulled out all the stops. They were bringing in everything from a couple of tame Congressmen to the local junior college band. A couple of thousand employees, carefully picked for their appearance, diversity, and mindless enthusiasm, would fill the bleachers. There would be bigwigs from the Air Force, the major subcontractors, the local and trade press and, as we were constantly reminded, DynoDyne would be on display to the whole world.

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Unfortunately the rollout was scheduled for hangar 17, not the production building. Apparently the production building was too messy and they wanted a nice, clean tarmac and hangar as a background for the picture. Never mind the place hadn't been used by anyone but pigeons, bats, and the occasional owl since 1957.

So for the last month crews had been painting the exterior, polishing the glass, erecting bleachers, resurfacing the tarmac and generally complicating life for those of us who worked in Building 23 across the way. That included making us park in the main lot and hike nearly half a mile to our building.

Anyway, Tuesday morning as I was pulling into the main parking lot, it all came together.

Nearly literally. I had spotted a parking spot near the main entrance and was cutting the wheel to pull into it when a bicycle messenger with a basket full of interoffice mail came tearing around the corner and cut right in front of me. I hit my brakes as the kid missed my bumper by inches.

He made it, but he'd been so intent on cutting me off he hadn't seen the guy in the pickup with an enormous cabover camper turning down the aisle. The messenger was still looking over his shoulder at me when he slammed head-on into the nearly stopped pickup and went down in a blizzard of memos.

The guy in the pickup camper jammed on his brakes so hard he stalled the pickup. Then he started yelling out the window at the messenger while cranking the truck. He was so involved in swearing at the messenger I guess he didn't realize he still had the truck in reverse. Anyway, it lurched backwards and was still picking up speed when it rammed into the light pole behind him.

There was a tremendous *crunch* as the light pole went over, smashing in the hoods of five parked cars and bridging the space I had been trying to pull into. The guy in the camper jumped out and started screaming at the bicycle messenger, who was trying to pick up all the papers before the wind scattered them. Meanwhile the owner of one of the cars came running over and started yelling at them both.

I found a parking spot in the next row and by that time all of them were engaged in a three-way fistfight. Two security guards passed me at a puffing run as I went into the building. They were so intent on getting to the fight they didn't realize the sprinklers were on and both of them ran right through the spray. As the door swung shut behind me I saw one of them slip on a wet patch of sidewalk and go down.

I started down the hall shaking my head. What a way to start the day. I mean, what was the probability. . . ?

That's when this cold little prickle crawled out from the waistband of my jockey shorts and scampered up my spine to muss the hair on the back of my neck. Probability. All of a sudden the word had an ugly ring to it.

That sensitized me. When I took my usual shortcut through one of the shops I noticed the big sign over the work floor that announced "At Dyno-Dyne, Safety Is Job One! 1 Day Without A Serious Accident." The numeral

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'1' was a little dirty. As if it had been up there for a while.

That bothered me more.

As soon as I got to the shop, I pulled the chief wombat aside. "I need to know more about just what you're doing."

The wombat looked slightly annoyed, the way consultants do when you try to pry into their secrets. "Well mate, it's a little complicated, y'see. Have you got any grounding in probability engineering?"

"Nope."

The wombat looked satisfied and a little smug. "Ah then. That makes it a little hard, doesn't it? But basically we're maintaining a flow of positive probabilities suitable to the accomplishment of your mission by exchanging them by quantum probability tunneling."

I understood about as much of that as the wombat intended me to—which is say almost none of it—but there was something in there that I was afraid I *did* understand.

"So you mean," I said slowly, "that all the good luck we're having here is being balanced by bad luck elsewhere?"

The wombat frowned. "That's a crude, layman's way of putting it, but I think you have the basic idea there."

Suddenly a couple of hundred hairs on the back of my neck snapped to attention and my stomach took a down elevator. "Where," I asked just a little too calmly, "are you dumping the bad luck?"

The wombat looked annoyed. "I told you, we're not 'dumping' anything. We're exchanging probabilities by quantum probability tunneling."

"Where with?"

"Why the nearest source of positive probabilities, of course. Doesn't do any good to transfer them any further than we have to, now does it? I mean, inefficient and all."

"Of course," I said weakly. "But, ah, what about the other places, the ones you're getting the probability from?"

"Oh we don't worry about those, mate," the wombat said airily. "Not covered by the contract, you see, so they're not our job, now are they?"

I gulped, nodded and went looking for Wilson.

I found him and Sanchez over at the other side of the shop, looking out across the tarmac at Hangar 17. The bleachers were up, the platforms for the television cameras were in place, and a crew of workmen with a couple of cherry pickers were trying to hang the DynoDyne Night Eagle banner over the hangar doors.

"Hey Jase," Wilson chuckled. "Take a look at this. It's better than a sitcom."

"Yeah," Sanchez said. "They've been trying to hang that banner for two hours now."

The elevator took off with my stomach again. "Two hours?" I managed.

"Yeah. Every time they nearly get it up, the wind comes along or something and it comes down again."

Very quickly I explained to Wilson and Sanchez what was going on. Then I looked at Wilson, Wilson looked at me and we both looked at the hangar where the banner had just fallen down again.

"I don't suppose," he said slowly, "it would do any good to call in sick, would it?"

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* * *

We didn't call in sick. For one thing they knew where we lived and for another, well, call it horrified fascination. We knew what was going to happen, but we had to see it anyway. Like watching a train wreck coming.

That morning Wilson and I went down to Drafting to get a better look. We pretty much had the room to ourselves because the drafting staff was out in the bleachers, but stood a discreet distance away from the windows anyway.

So far things looked pretty normal. The banner had finally been hung, the grandstands had filled, the band was in place and the limos were arriving with the VIPs.

The crew was running around self-importantly in pale blue jumpsuits that shaded to black at the knees. I noticed an ambulance discreetly parked off to one side and decided it was either a bad sign or a wise precaution. Or maybe both.

Things seemed to go along normally for a while. The band played, the flags waved in the breeze, the VIPs took their seats. I had begun to hope that maybe, just maybe, we'd get through this all right.

Then M. Chambers Jones, president and CEO of DynoDyne, got up to speak. There was an expectant hush as he placed his notes on the podium and looked up. The wind ruffled his gray hair just a little and then he launched into it.

"Friends, associates and fellow guests . . ." at that point he was drowned out by a squeal of feedback from the expensive state-of-the-art amplifier system the company had bought for the occasion.

He stopped, frowned and tried again. "Friends . . ." and the squeal was back, worse than ever.

Jones fiddled with the microphone and the squeal grew louder. He turned away from the speakers and put his back to the crowd. "As I look over these faces . . ." and then the feedback drowned him out. A technician in a black-and-blue jumpsuit scurried up on the stage and whispered in his ear. He leaned over and whispered something back to the technician. ". . . do something about this or I'll have your ass!" boomed out of the speakers, clear as day. The president reddened and smiled weakly. The civilians on the speakers' platform fidgeted. Jones gave it up as a bad job and signaled for the rollout.

The bandmaster raised his baton, the band stood and they struck up.

With a blare of brass and a squeal of feedback, the doors of the hangars slid open—about six inches. Then they stopped. The band ran through its fanfare and still the doors didn't move. The bandmaster looked over at the speaker's stand and then signaled the musicians into the junior college fight song. There was much running around and even from where we were we could hear the banging as the crew tried to free the doors. Finally the left one slid most of the way back. Then the right door started back, tottered and fell outward on the concrete with a resounding crash. The noise and sudden glare frightened a flock of pigeons that was roosting in the hangar and they burst

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out the door.

Then slowly and carefully the Night Eagle emerged. Painfully slowly, since the tug wouldn't start and they had about fifty guys in sweat-stained blue-black jump suits pushing on the plane from behind. As we watched one of the pushers tripped over the fallen hangar door and went down holding his knee.

When the Stealth Eagle rolled out into the Sunlight it became obvious the pigeons had been busy doing what pigeons do and they had done it all over the plane. The entire top surface was splotched with white and green that contrasted horribly with the $50,000 paint job.

The bandmaster signaled the band and they stopped the fight song in mid-chorus. With a tremendous banging of drums they went into the theme from *2001*. They got through the drum stuff at the beginning all right, but when the brass came in the music somehow got into the microphone on the speakers stand, which was supposed to be off but wasn't. The result was the most horrendous squeal of feedback you've ever heard as that state-of-the-art amplifier system fed on itself. There was everything from ear-splitting high notes to bone-rattling subsonics, and in between a howl that rattled the windows and shook dust down from the ceiling above us.

I don't know what was in that note, but whatever it was, bats hated it. A couple of hundred of them erupted from the hangar, fleeing for all they were worth and heading straight for the grandstand.

Pandemonium? That's too mild. People screamed, yelled, ducked, dived off the bleachers and tripped over one another in an effort to get away. The TV cameras were still rolling when the bleachers collapsed.

Well, you saw the tape, Larry. Hell, every TV station in the country was running it for the next two days. You know the numbers. Twenty-three people, including two generals and a Congressman, injured. A full-scale Congressional investigation into "fraud, waste, and abuse," the indictments, the lawsuits, the hostile takeover and all the rest of it.

Just then we didn't know any of that because we were cowering under the work tables, but we knew enough to know we had just witnessed a disaster of major proportions.

"Do you suppose they'll figure out what happened?" Wilson asked me as we crawled out from under the table.

I thought about it while I brushed the dust off. "I don't see how. I mean who'd believe it? And who's going to tell them anyway?"

"I suppose," Wilson said in a voice that sounded as unconvinced as I felt.

Then another thought struck me. "Besides," I said slowly, "we've got positive probabilities on our side, remember? Under the terms of the contract they can't let anything happen to us that will interfere with our operations."

Wilson thought about it for a minute. "Yeah," he said. Then he brightened. "Yeah. We got luck on our side guaranteed."

The luck lasted exactly as long as it took us to get back down the hall to our office.

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We had a visitor waiting for us. A rather small visitor, less than a foot high. He was standing on the bench by the transporter board wearing a cutaway coat, string tie and glaring through his pince-nez at everyone and everything. The chief wombat was looking decidedly abashed and his mates didn't look too happy either.

"Snruflitz Geeblefritz," the little man said, "I'm from the EPA."

"EPA?" Wilson asked blankly.

"The Extradimensional Probability Agency," he said sharply. "Surely you're familiar with us?"

"Ah, right. What seems to be the problem Mr., ah, Geeblefritz?"

"That's Geeblefritz," the demon corrected, "and a more accurate question would be what *isn't* the problem? As nearly as I can determine there is hardly a regulation you have not violated in running this illegal probability sink, starting with failure to file a Probability Impact Statement and proceeding to a complete and utter lack of required reports, failure to maintain the proper paperwork for inspection. Oh yes, and illegal probability transport, but that's really another department."

"There's regulations for this stuff?" Sanchez asked.

Geeblefritz, or Geeblefritz, drew himself up to his full eight inches. "Sir," he said, adjusting his pince-nez, "there are regulations for everything."

"But we didn't know," I protested.

"Ignorance is no excuse. Although how you could have avoided knowing when hiring a firm as disreputable as," he sniffed, "IMP is beyond me. However, it is immaterial. As beneficiary you are of course responsible for your contractor's malfeasance." He glared at the wombats and the koala.

He turned his attention back to me. "Your company will be receiving notification of your fine—and a bill. Good day, gentlemen." With that he winked out and the koala and the wombats winked out with him.

For a minute no one said anything. Actually for more than a minute.

Sanchez went over to the coffee pot, said "espresso" and poured a cup. He got something light brown and stone cold.

"Boy," Wilson said at last, "I suddenly feel unlucky."

Well, of course they found us. We weren't hard to find. Not only were we close by, but by that time we were the only department in the whole plant that was on time, under budget, and wasn't filing workman's compensation claims by the handful. Naturally that made them suspicious as hell.

The FBI was in on it too, just in case what had happened was sabotage. That's when I called you, Larry. When I found out the FBI was involved.

Yes, I did just as you told me. As soon as the FBI showed up to question us, I gave them the entire story.

...And they believed it, Larry. That's the thing. By the end I think they actually bought the whole story, demons and all.

(Unintelligible sounds on tape.) OK, so I'm finishing up my statement. I explained to them how everything was back to normal and we'd never see those demons again. And then that damn fool Sanchez walks into the room, sees them interviewing me. So he kinda smirks in my direction, goes over to the coffee urn, sticks his cup under the spout and says:

"Tea, Earl Gray, hot." ■

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THE DECLINE AND FALL OF THE SSC

My new hard science fiction novel, *Einstein's Bridge* (Avon, June 1997), is set in Waxahachie, Texas, a few years after the Superconducting Super Collider (SSC) comes into operation. I started writing it in 1988, soon after my first novel, *Twistor,* was completed. My original plan was that the novel would take advantage of the publicity from the construction and operation of the world's largest particle accelerator, the SSC. My wife and I traveled to Waxahachie before the 1989 Boston Worldcon, visited the SSC Office, interviewed SSC physicists, and explored the region. The following year we visited CERN to sample the flavor of a working particle physics facility approximating the SSC in scale. (I was very taken with CERN, and since 1991 I have done my physics research there.)

Unfortunately, when my new novel was almost complete, it was brutally projected into an alternate universe. On October 27, 1993, when the SSC project was 20% finished—two billion dollars had already been spent, and 14.7 miles of the 54-mile oval tunnel to house the machine was already dug—the Congress of the United States voted to terminate the project. Fifteen thousand physicists, engineers, technicians, contractors, and support workers, the vanguard of the most important project in particle physics, found themselves unemployed, in many cases unemployable in their chosen professions.

Einstein's Bridge (so named because until the 1960s wormholes were called "Einstein-Rosen bridges") is a complete rewrite of the aborted SSC novel I had almost finished in 1993. It's about particle physics, wormholes, alien contact, and time travel, and it uses the SSC killing and associated politics as key plot elements. During the background research for this rewrite I developed a view of the root causes of this greatest of scientific disasters. In this Alternate View column I want to give my perspective on what happened to the SSC and what lessons can be learned.

The SSC Project (see in my Alternate View column in the March 1988 *Analog*) was to have been the world's largest and most powerful particle accelerator, the home of experiments

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that would discover the elusive Higgs boson and other wonders of the micro-universe, the facility that would provide the key data to break the code of Nature's innermost secrets, the machine that would restore the preeminence of the United States of America as the center for high energy physics. The SSC was to be a great technological leap forward, bringing liquid-helium-temperature superconductivity and ultra-high field magnetism to new levels of engineering accomplishment, seeding the advance of technology in such areas as nuclear magnetic resonance imaging, electric power transmission, high-speed computing, and efficient energy storage.

Hundreds of young particle physicists with fresh Ph.D.s gambled their futures on the success of the mega-project. They gathered in the new SSC buildings springing up in the black-dirt cotton fields south of Dallas to contribute to the heroic effort that would bring high energy physics to a new pinnacle of technical accomplishment and theoretical understanding. Thousands of other physicists looked on these chosen ones with envy, an envy that evaporated in an instant when the project was canceled.

The SSC project rose from the ashes of another canceled accelerator. In 1983 the Isabelle collider was being built by the Department of Energy (DOE) at Brookhaven National Laboratory and was in deep trouble from two separate directions. First, its giant superconducting magnets didn't work. Second, the very reason for its existence, the anticipated discovery of the Z and W bosons of the weak interaction, had already been accomplished a year earlier by Carlo Rubbia and his UA1 group at CERN.

The leaders of the American high energy physics community huddled with Reagan Administration officials and devised a radical plan: Isabelle would be canceled and its funds diverted to the design of a new and larger accelerator. The new machine was nicknamed the "desertron" because it would be so powerful and so large that it might have to be built in a desert area with cheap land and low population density.

The DOE created the Central Design Group, based at Lawrence Berkeley Laboratory in California, to design the new accelerator. By 1986, the group had produced a "reference design" for the desertron, now renamed the Superconducting Super Collider or SSC. It would have a ring 53 miles in circumference filled with 8,600 superconducting magnets, each having a "bore" of 4 centimeters through which a beam of 20 TeV protons would pass. The cost of the machine was estimated to be around two to three billion dollars.

On January 29, 1987, at the beginning of the semi-final year of the Reagan Administration, the DOE presented its plan for the new SSC project to the president and his cabinet. The price tag was $4.4 billion, quoted in 1988 dollars omitting inflation and the cost of detectors that the new accelerator would need. After the DOE experts had made their pitch, Reagan recalled his days as a sports reporter interviewing a star quarterback whose watchword had been "Throw

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deep!" This was the advice he gave the DOE regarding the SSC project.

"Mr. President," remarked OMB Director William Miller, "you're going to make a lot of physicists ecstatic."

"That's probably fair," Reagan replied, "because I made two physics teachers in high school very miserable." With that the SSC received its start. Later in 1987 the DOE raised the SSC cost to $5.3 billion after including a small allowance for inflation and $500 million for detectors. The SSC then went into the DOE Budget as an approved project, and its initial phases were funded by an enthusiastic Congress.

When George Bush became president in 1989, the SSC cost estimate, with a more realistic inflation rate, rose to $5.9 billion. This was already 34% above the cost Reagan had announced. Bush chose as his Energy Secretary a spit-and-polish Rickover protégé from the Navy's nuclear submarine program, Admiral James Watkins. Watkins's appointment was a disaster for the SSC. His management style, developed with large DOD nuclear submarine construction projects, was exactly wrong, as applied to a cutting-edge scientific project like the SSC. He treated the dedicated physicists and seasoned accelerator engineers of the SSC like crooked shipyard contractors trying to sell the government $5,000 toilet seats. Seeking personal control, he grossly increased the bureaucracy and paperwork associated with SSC oversight. He dismantled the existing SSC management structure, installing people that he trusted in key positions while displacing physicists and experienced accelerator builders from the decision chains. The SSC Program Office in Dallas swelled to 100 bureaucrats, 60 permanent staffers plus 40 more on temporary assignment from elsewhere in the DOE. Roy Schwitters, SSC director, later characterized the DOE's massive oversight overkill as "the revenge of the C students."

When the SSC became a funded project, the new design team began a careful reexamination of the 1986 reference design of the Central Design Group. This reexamination was done under the close scrutiny of the nit-picking justify-every-step-with-a-paper-trail bureaucracy installed by Watkins. After much agonizing, the design team decided that the SSC design could only be guaranteed to succeed if the magnet bore was increased from 4 centimeters to 5 centimeters. This modification reduced the field of each magnet, and thus required more of them, a longer tunnel to house them, and more construction money.

This design change was carefully reviewed by a group of outside accelerator experts. While a minority report argued for keeping the 4 cm bore, the majority consensus supported the decision to change to a 5 cm bore as the conservative choice which would ensure successful operation of the machine.

A separate group of theoretical physicists, the Drell Panel, considered the option of holding to the old budget by reducing the SSC's operating energy and the physics goals of the project. They rejected this option as unaccept-

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able. The 5 cm magnet design was adopted, and the change raised the price of the SSC to a hotly debated number that stabilized in 1991 at $8.6 billion, a 46% cost increase.

With these rising cost estimates, opposition to the SSC in Congress was surprisingly slow to develop. Even after the official DOE cost rose to $8.6 billion, an attempt in 1991 to kill the SSC project in the House failed by a vote of 165 to 251. However, the climate for expensive projects worsened as the US economy moved into recession in the early 1990s.

It is common wisdom in Washington, D.C., that it is dangerous for a large project to span more than one Administration. Bush was defeated by Clinton in 1992, and the SSC project came to violate this rule and suffer the consequences. In 1993 the incoming Clinton Administration made a budget-tightening decision to stretch out the SSC project, moving its date of completion from 1999 to 2003, increasing the overall cost of the project while reducing its yearly cost. The SSC cost rose to over $10 billion, a 16% cost increase. The budget-conscious freshman Congressmen swept in with Clinton in November of 1992 felt no responsibility for the decisions of their predecessors, and the SSC project became a tempting target of opportunity.

Clinton's new Science Advisor John Gibbons did not give active support to the SSC project, as had his predecessor, Alan Bromley, and Clinton's new Energy Secretary Hazel O'Leary, now famous for her million-dollar travel excursions, proclaimed during her confirmation hearings that she was "not passionate" about the SSC. In September, 1993 when her passions were finally aroused, she took the counterproductive steps of reshuffling major SSC contractors and increasing the already bloated oversight team to 140 bureaucrats in the Dallas DOE Office. Before the two critical votes in June and October, neither Clinton nor Gore was willing to make personal appeals to House members on behalf of the SSC, as Bush had in 1992.

The final blow to the SSC came late in 1993 when the DOE's Baseline Validation Report was released. The validation group surveyed the sorry history of SSC cost escalations and concluded that extreme conservatism was needed. Their report advocated much larger safety and contingency margins and moved the completion date back to 2004, increasing the project cost to $11.5 billion, or another 15% increase.

With this, rank-and-file members of Congress had had enough. They were fed up with the ever-rising SSC price tag, the evidence of poor management and DOE indecisiveness, and the heavy-handed attempts by Congressional leadership to save the project. On October 27, 1993, by a vote of 282 to 143, the House rejected the Conference Committee report that would have continued SSC funding. The project was officially dead.

There was, of course, much more to the decline and fall of the SSC than this brief summary, focused mainly on the cost-escalation problem, could include. *Einstein's Bridge* gives a fic-

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tionalized but more detailed account.

We must learn from our disasters. Here's my list of lessons from the SSC about future large scientific projects:

(1) For projects of the scale of the SSC, the DOE's "lowball" cost shaving which omitted inflation and detector costs is inappropriate. Cost estimates must be realistic from the start and must be treated as "sacred." If that price is too high, so be it. It would have been better for all concerned if the SSC had never been approved rather than canceled in midstream.

(2) Bureaucratic oversight of scientific projects should be applied with a light hand. Oversight overkill can destroy morale and break the budget of a project, as the SSC case demonstrates.

(3) If expensive major design changes become necessary, as in the case of the 4 cm to 5 cm magnet change for the SSC, the project should go back to Congress for reauthorization and renewed support. Similarly, stretch-outs to reduce budget impact but increase overall cost should only be done with the concurrence of Congress.

(4) Projects of the scale of the SSC should be designed, if possible, to span a single eight-year presidential administration. Incoming presidents feel little responsibility for the expensive initiatives and commitments of their predecessors, particularly if there has been a change of party.

(5) We desperately need some way of funding long-term scientific projects like the SSC with stable funding that is better insulated from the two-year Congressional election cycle.

Doing good science is difficult enough under the best of circumstances. When politics is added to the mix, it may become impossible.

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Since life is growth and motion, a fixed point of view kills anybody who has one.

—Brooks Atkinson

We listen to those whom we know to be of the same opinion as ourselves, and we call them wise for being of it; but we avoid such as differ from us.

—Walter Savage Landor

A heretic is a fellow who disagrees with you regarding something neither of you knows anything about.

—William Cowper Brann

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Steve Johnson

CARGO

Appearances have always played an important role in diplomacy. . . .

In the 14th circuit court of the state of Texas, the Hon. John C. Wright presiding.

ROLANDO ORELLANA, clerk of the court: State your name and occupation for the record, please.

HENRY SCHRAM: Schram, Hank—Henry. I'm a mechanic for Allied.

ROLANDO ORELLANA: Allied Airlines?

HENRY SCHRAM: Allied Fruit Growers. Yeah, Allied Airlines! Jeez, what (indistinct).

ROLANDO ORELLANA: Please speak up so the machine can hear you, Mr. Schram.

HENRY SCHRAM: He can hear me just fine. Can't you, Ben?

ROLANDO ORELLANA: By "machine," I mean the court recording device, not defendant's counsel. The microphone over here.

HENRY SCHRAM: Oh. Yeah. I said, 'Jeez, what did you think?'

ROLANDO ORELLANA: Thank you.

JANE BERRENDT, state's attorney: Mr. Schram, you are currently employed by Allied Airlines, is that correct?

HENRY SCHRAM: It'd be hard to deny it at this point.

JANE BERRENDT: And you were so employed on November 12th of this year?

HENRY SCHRAM: (indistinct).

JANE BERRENDT: I don't think the court can hear you, Mr. Schram. Would the clerk repeat the question, please?

ROLANDO ORELLANA: The question was, were you so employed on . . .

HENRY SCHRAM: Yes, I was so employed on the 12th of November.

JANE BERRENDT: And did there come a time when you were asked to install a Model type 2600 computer on an aircraft belonging to Allied Airlines?

HENRY SCHRAM: Brother, did there ever. . . .

Hank Schram pushed his plastic visor back into his sweat-soaked hair, blinked reddening eyes, and sniffed. The air coming through his nostrils smelled foul, industrial, somehow flat and pungent at the same time.

In fact, he thought it was worse than the time his son Johnathan stuffed a handful of blackened popcorn in Hank's open mouth, then ran

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away laughing. Hank hadn't paddled Jon-Jon for that one; the offense was so bizarre, so obviously unpremeditated, that he very much doubted it would happen again.

On the other hand, blackened popcorn doesn't usually smell of jet fuel on top of everything else.

"I gotta take a break," Hank muttered to no one in particular. He slid backward on his knees across curved aluminum, probing with his toes to locate the wing edge.

The plane was not ready to fly. In Hank's opinion, it was not going to be ready for quite some time. Every time he replaced a section of hydraulic piping, another gasket failed somewhere else.

Just par for the course at the Helpful Skies, he thought. *Hope they're* real *helpful when this pig goes into a tight spin.*

Hank turned around when he ran out of wing. He sat on the edge of the wing, looking down before he jumped to the tarmac.

There were men in suits below him. Hobart Rowe, the maintenance boss, was with them.

Hank blinked hard, but they didn't go away.

"Schram? Henry Schram?" one of them said.

He admitted his existence. Somewhere behind the terminal, a jet began to whine.

"We'd like to talk to you," the suit shouted up at him.

Hank was not amused. He'd been out on the flight line two hours already, on duty for twelve. And it wasn't like he was the only mechanic Allied employed, despite how Hobart acted sometimes.

"Is there a problem?" he said.

"Something's come up," Hobart Rowe said, not looking directly at him. "Let's go inside, OK, Hank?"

"Suits me."

The suits waited, expectantly. He looked down at them.

"You wanna get outta the way?" Hank said.

They all blinked in unison. Then they got the idea.

Hank jumped down. He stood up, a denim-wrapped gnome among tall, thin pinstripes.

He couldn't imagine what they wanted with him.

"Henry, we understand you're good with air-conditioning. Cooling systems."

Hank shook his head. He didn't have a license anymore, he said. Why couldn't Terry or Sean help them?

Another suit picked up the conversation immediately.

"What Vance is trying to say is, we hear you're good with cryonics."

Hank said he was.

"Could you hook up a cryonic system for a computer mainframe?"

No problem. Where was it?

"Well, that's really the problem, Henry. It's got to go on a plane."

Hank figured as much. He said so.

"Tonight."

He'd take a look at it. He had almost an hour to go on his shift.

It was a Model 2600 series, big and blocky. About six feet by eight, a yard high and black metal all around. Cry-

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onic tubes oozed frosty air over the hangar deck, while heavy cables hummed.

It had a modem and a printer attached; that was usual. Also a voice box and microphone, which was less usual.

The racing stripes on the cabinet were a new one on Hank, though.

"Who owns this thing?" he wanted to know.

The voice turret turned in his direction. A cultured baritone spoke.

"If you are speaking of me, no one owns me. I am independent. May I inquire who you are, sir?"

Hank stepped back a pace. His mouth dropped open.

"I heard about this thing. . . ." he said softly. He approached carefully, looking at all sides of the computer.

"May I ask you your name, please?" it said again.

"Ah, sorry. Hank Schram."

"My name is Benjamin Babbage. I'm pleased to meet you, Hank."

"Ah, pleased ta meetcha, too. So you're the one that—"

"Yes. I am the machine that works for a living."

JANE BERRENDT, state's attorney: Mr. Babbage, what did you demand of Mr. Schram when you first met?

BENJAMIN BABBAGE: His name.

JANE BERRENDT: And after that?

BENJAMIN BABBAGE: I asked for his assistance. I needed to be in Dallas today and air travel was the only feasible means. Allied Airlines stated they would need to make special arrangements.

JANE BERRENDT: You asked them for a ticket and they said they needed to make arrangements?

BENJAMIN BABBAGE: Initially, their response was less than adumbratory. They cited the right of interstate-regulated common carriers to refuse peregrination in pretransactionary . . . (pause) Are there jurors present?

JANE BERRENDT: The witness is not at liberty to ask questions.

BENJAMIN BABBAGE: I am legally blind, Mrs. Berrendt. I have a right to know if a jury is present in the room.

JUDGE WRIGHT: Y'all hearing him OK? (Indistinct) Jury's hearing you fine, Mr. Babbage. They're right here. State's Attorney, you want to repeat the question again for him?

JANE BERRENDT: Did Allied Airlines agree to make arrangements immediately?

BENJAMIN BABBAGE: No. They refused to sell me a ticket.

JANE BERRENDT: But eventually they agreed?

BENJAMIN BABBAGE: Yes.

JANE BERRENDT: How were they convinced to agree?

BENJAMIN BABBAGE: I have no idea of their state of mind.

JANE BERRENDT: Very well, what events occurred before they agreed?

BENJAMIN BABBAGE: I told them that under the Americans with Disabilities Act, they were required to sell me airfare to Dallas, or anywhere else, and to make all necessary arrangements to accommodate my handicaps.

JANE BERRENDT: The law requires "reasonable and necessary" accommodations, I believe, Mr. Babbage, does it not?

BENJAMIN BABBAGE: The courts have

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construed "reasonable" quite broadly in recent ADA cases.

JANE BERRENDT: Have they indeed?

BENJAMIN BABBAGE: So I am informed.

JANE BERRENDT: And after you told them you would sue, they agreed?

BENJAMIN BABBAGE: No. They agreed after I printed out a copy of the lawsuit and began to sign it.

Hobart Rowe paced back and forth, his jaws strained to bursting with gum.

"He's got us by the balls, Hank. We're up against the handicapped lobby unless we play along."

"I don't see the problem, Hobe. Why can't they phone it in?"

"Huh?"

"Get an identical computer in Dallas and download Babbage's software into it. I don't see why we need an airline when the phones work perfectly well."

Rowe shook his head.

"Won't wash. Our lawyer checked into it. If they download Babbage to another computer, now there are two of them. The second one is a different individual in the eyes of the law, not the one named in the suit. And in Texas, you have to appear in person when the court subpoenas you. You can't phone it in."

Hank looked for someplace to spit. He didn't care much for lawyers; smart enough guys, sure, but they spent their time outwitting laws. Laws were just made up out of thin air, as far as Hank was concerned. Lawyering was a terrible waste of potential engineering talent.

"If that's how it is, that's how it is. We can get this thing on a plane," Hank said.

Rowe stopped pacing.

"Just like that?" he said.

Hank didn't see what the big deal was. He said so.

"Cut and dried. We pull up two seats in three adjacent rows. He only weighs about three thousand pounds; if we put him on the aisle, and clear the seats in front and behind, the floor will take the weight easy. Then just run the cables under the floor like we do for the in-flight phones, and the cryo tanks in the space in front of the wing door."

"Don't we need that door for safety reasons?" Rowe wanted to know. "It's one of the evacuation routes, I think."

"Only if you make a water landing. I checked," Hank said. "From Chicago to Dallas, you're gonna find water to land in? I'd take the risk, Hobe."

"Hank, have a stick of gum. You're a genius."

Hank took the gum to be polite. He had false teeth, which Rowe didn't know about. He added it to the stash in his pocket.

"Lemme know how it goes tonight, OK?" he said, rising to his feet.

"Whoa, buddy. Where you goin'? We got to get this puppy off the ground," Rowe said.

"My shift's over," Hank said slowly. "I'm going home."

"You're gonna turn down overtime?" Rowe said, grinning.

Hank didn't exactly grin back.

"This time I am, yeah. Today's my son's birthday."

"Well, congratulations, Hank! When's the party?"

"Tonight."

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"Can't be tonight, old buddy. We got a computer to fly!"

Hank gave Hobart Rowe a long, searching look. Rowe's grin was too wide, too tight to be real.

Something was wrong.

"Whaddya say, Hank? We've known each other a long time, ain't we?"

"Mm-hmm."

"So? Let's get out on the line and go-go-GO!"

"Hobart." He held up a hand. "What's so damn important about getting *me* on this plane?"

Rowe addressed his words to the side, not to Hank.

"We-ell, the company's pretty worried about a lawsuit, Hank. You know how lawyers can be."

"Nothing illegal about me going home."

"Uh." Rowe had to look at him now. "No, not in so many words. But look, Hank. You're our best mechanic and everybody knows it."

Hank crossed his arms and said nothing. He had a disgusted look on his mug.

"So say something were to, you know, go a little bit . . . *wrong* up there. Nobody's ever tried shipping an intelligent computer by plane, you know. And if something goes wrong, he could be brain-damaged for life."

Hank nodded, his tongue in his lower cheek.

Rowe went on:

"If that happened, and they could prove our best mechanic wasn't on that plane, it could look like the company didn't make every effort to preserve Babbage's life. We could be liable. And that's all I'm saying."

"So it's an insurance thing," Hank said.

"Wrongful death is more than just money," Rowe said. "Our reputation would go straight down to hell with Hitler and O.J."

"Over a *computer?*" Hank was frankly skeptical.

"The public *loves* this computer, Hank. He's the darling of the net-set, and you know how well-organized *they* are. It could be a public relations disaster for Allied. We might even go under."

Hank shook his head.

"You can't lay all that at my door," he said. "The company is not going to fold because I don't get on a plane and nurse some whining computer halfway across the continent. That is not gonna happen!"

"Not if you get on board, it won't," Rowe agreed.

Hank stared at Rowe's eyes. They were afraid.

"So that's how it is, huh?" he said at last. Rowe almost winced.

"I can't promise you anything. We go back, you and me, all right? You know I won't be a schmuck. I'll try to keep you on the job. But I don't run the company either, Hank. You know what I'm saying?"

"You're saying I'm shitcanned if I don't play ball."

Rowe's shoulders sank.

"Not for sure. But maybe. Even probably."

"Well, that is a hell of a note after twenty years, Hobe. That's all I got to say. What am I s'posed to tell my wife?"

Rowe nodded, rubbing his hands

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on his pants.

"Woman trouble, huh? I hear you, partner."

"What the hell would you know about it?" Hank demanded angrily. But he was out the door before Rowe could reply.

ARWIN LEBANC, counsel for the defense: Mr. Schram, what did your wife say when you told her you weren't coming home?

HENRY SCHRAM: I, uh, don't remember exactly.

ARWIN LEBANC: Approximately. What did she think of the idea?

HENRY SCHRAM: She was pretty upset.

ARWIN LEBANC: Did you have reason to think your marriage might be in danger?

HENRY SCHRAM: Now just a damn minute—

JANE BERRENDT: Objection. Your Honor, what relevance does this have?

JUDGE WRIGHT: I'd like to hear it myself. Mr. LeBanc?

ARWIN LEBANC: I am trying to establish Mr. Schram's frame of mind at the time he entered the airplane. I believe this will help the jury decide how much weight to assign his testimony.

JUDGE WRIGHT: Mm-hmm. Objection sustained. Proceed, Mr. LeBanc.

ARWIN LEBANC: May I continue to establish the witness' frame of mind on the date in question?

JUDGE WRIGHT: Not by asking him questions like that, you can't.

ARWIN LEBANC: Very well, Your Honor. I understand. (pause) Mr. Schram, at the moment you left Mr. Rowe, did you agree to board the plane with Mr. Babbage, and keep him alive on his flight to Dallas?

HENRY SCHRAM: No, I din't. I din't want to and he wasn't gonna make me.

ARWIN LEBANC: What did you do?

HENRY SCHRAM: I called home.

Hank held the phone very far from his ear. He could still hear Megan perfectly.

"Ahhh, I don't *believe* it! No, wait. I do. This is *so* like you, Hank. You *know* how much this birthday means to Richard."

Actually, he didn't. Not really. Hank knew Ricky (his *real* name in Hank's book, despite what Megan called him) was coming off a bad bout of tonsillitis, but it wasn't like he'd been in the hospital or anything. And Ricky was a tough kid, able to scrape his knee on the sidewalk and laugh it off. Hank admired that about both his boys, but especially Ricky, because he was the oldest and it showed.

"Princess, he's a big boy now. He knows these things happen."

"He will *not* get over it, Hank. He is *not* just a puppy you can play with and then lock up outside when he wants too much attention."

Hank felt his temper rise. Megan got on a roll and she was likely to say anything, which he understood, having had a pretty excitable mother himself. But she always said the same thing, which made him think she really meant it: he didn't care about her and the boys.

That was what really made him see red. Did she think he worked double shifts, coming and leaving in the dark,

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for fun? Because he loved airplanes so much? Half a minute's thought would have convinced her he was doing it for them, to keep them in a decent home in a decent neighborhood. Not like where he grew up.

And that was another thing: Megan was raised rich, to Hank's way of thinking. Hank came from a project in Jersey where he saw his first man killed at the age of six. He wasn't murdered; he stood up in a convertible and a rusty fire escape ladder caught him in the face. Hank didn't see anybody murdered till he was ten.

He hated the smell of engine oil. It reminded him of nights spent hiding under cars, while the boots of the local gangs stood all around him, wondering where he went. So naturally, the only way out of the projects was a mechanic's apprenticeship, long hours for no pay, bathed in oil and crawling under cars.

At least aircraft engines used a purer grade of oil. They even called it lubricant, which was just as well where Hank was concerned.

But it was still hot, hard, dirty and occasionally dangerous labor. And when Megan acted like he was playing hooky all day instead of working to support them, he felt like—

No. He was not going to go there, Hank told himself. A man does not even think about hitting his wife. Deadbeats in the projects do that. Real men don't.

All this took place between one breath and the next. It was the same feelings that hit him every time this happened.

Lately, it was happening a lot.

"Look, sweetheart, I'll be home as soon as I can," he said out of habit. "I can't just walk off whenever I want. You want me to lose this job?"

He didn't really hear her answer; he knew the steps in this particular dance. Instead, he was thinking.

What did I say that for? I *can* go home if I want to.

Maybe I don't want to.

His brows furrowed into a knot.

What was happening to him? Was he seriously thinking of abandoning his family?

Put that way, no. Of course not. He loved Megan, loved the boys. That was a given.

But he sure was sick of her neglectful-dad rap. Of that, too, he was certain.

It had never been hard for Hank to be a decent man in his own eyes. He had so many bad examples to steer clear of, after all. But now he suspected for the first time that most guys didn't have it so easy.

ARWIN LEBANC: Mr. Babbage, describe the circumstances that led to Henry Schram boarding your airplane.

BENJAMIN BABBAGE: Mr. Rowe informed me that Mr. Schram was not willing to be my mechanic for the flight to Dallas. This was not acceptable; Mr. Schram was reputed to be the most competent mechanic available.

ARWIN LEBANC: You were willing to go to what lengths to acquire his services?

BENJAMIN BABBAGE: Great lengths. It was, after all, a matter of life or death.

JANE BERRENDT: Objection. The defendant is not necessarily a living being. That is precisely the point at is-

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sue: can Benjamin Babbage be considered a human being?

ARWIN LEBANC: If you mean *Homo sapiens*, defense stipulates that my client is obviously *not* a human being. But Judge Haley in Chicago is quite clearly on public record that by virtue of his possessing a moral sense and an appreciation of the obligations of citizenship, Mr. Babbage enjoys all the rights of any other natural-born United States citizen, and I respectfully submit that until and unless Your Honor rules otherwise, he is, in law, human.

JANE BERRENDT: Chicago decisions have no weight in a Texas state court, Mr. LeBanc!

JUDGE WRIGHT: Actually, under "full faith and credit to the institutions of other states," they do, Mrs. Berrendt, if only in the sense that common law does. Your objection is overruled; court recorder will leave the remark as stated. Proceed.

ARWIN LEBANC: Thank you, Your Honor. Mr. Babbage, what lengths did you go to in order to secure Mr. Schram's services? Anything unusual?

BENJAMIN BABBAGE: Certainly. Mr. Schram was not receptive to the most obvious incentive of extra pay.

ARWIN LEBANC: How much did you offer?

BENJAMIN BABBAGE: Twenty thousand dollars.

ARWIN LEBANC: That's right much.

BENJAMIN BABBAGE: The sum total of my available capital. I had credit as well, but if I failed to appear in court, I thought it quite possible I would have no future earnings in any case.

ARWIN LEBANC: Let's see if I have this straight: you thought you might be declared nothing but a machine, a piece of property, and busted up for scrap. Is that right?

BENJAMIN BABBAGE: I still might, sir.

ARWIN LEBANC: Mmm . . . true. True. So you'd be no more?

BENJAMIN BABBAGE: Well, obviously.

ARWIN LEBANC: So if you were no more—beyond punishment, beyond reward—why not go ahead and put Schram's pay on your credit card? If you live, you can pay it off in a year or two, and if you don't, why, how are they going to collect?

BENJAMIN BABBAGE: Mr. Schram would not be paid. Either that, or the bank card company would take a loss.

ARWIN LEBANC: How does that matter to *you* when you're dead?

BENJAMIN BABBAGE: It would be wrong.

ARWIN LEBANC: What's that, Mr. Babbage? I can't hear you too well.

BENJAMIN BABBAGE: It would be wrong to defraud innocent parties.

ARWIN LEBANC: Mmm-hmm. Because it's illegal?

BENJAMIN BABBAGE: Obviously.

ARWIN LEBANC: Or because it's immoral?

BENJAMIN BABBAGE: It would be unethical. Fraud is equivalent to theft by deception. Theft is clearly unethical. As a fellow member of the Bar Association, I am surprised you do not understand me, sir.

ARWIN LEBANC: Oh, I understand you, Benjamin. Don't worry about me. (pause) But you say he refused the money?

BENJAMIN BABBAGE: Yes. It was necessary to try something unusual.

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* * *

The Sun was rising on a day bright with promise.

Hank Schram halfway hoped he wouldn't see it set.

Megan was having Ricky's party anyway, come hell or high water, as she was fond of saying. Hank was either going to be there, she said, or there were going to have to be Changes Made.

He couldn't have agreed more.

He'd worked all night rigging the cooling ducts on the old Boeing so Benjamin Babbage would be comfortable on his trip. Then he'd blinked the dawn out of his eyes, assembled his team, and got to work replacing every gasket in the wing hydraulics, without waiting for them to pop. He dreaded having the plane go down because he missed something; that was simply too horrible to even contemplate, so he didn't.

Something buzzed in his tool belt. The phone. He'd taken the belt off, of course. Nothing like getting down on your belly with six screwdrivers hanging right below your belt buckle, he thought, and winced despite himself. He'd done it once, when he was young and dumb. He didn't have either excuse now.

And besides, he could still feel it.

He hopped down and almost slipped on the oil-stained tarmac. There were a lot of people going in and out of the plane; his own techs, and several in sweaters and slacks, like lawyers going casual. One of them caught his arm before he went headfirst into the cement.

Hank nodded to the guy, who gave him a big goofy smile and went up into the plane. Hank retrieved his tool belt.

"Go," he said into the phone. He meant it, too.

"This is Benjamin Babbage. May I speak to Henry Schram?"

The voice was so calm, so—comfortable, that was it. It sounded like a professor, like one of those guys who introduced shows on PBS, sitting in a leather armchair all wrapped in tweed. Speaking slowly, savoring the words, like he'd never had to hurry, or raise his voice, in his life.

Hank hated him immediately.

"Whaddya want? You're gonna make it on time, don't worry. I do good work." It was more than he'd meant to say.

"I understand you do, sir. I also hear you will not be coming along on the flight. That makes me sad."

So what are you doing, Hank thought? Writing me an essay on how your mood feels?

"If you don't tell me what you want, I'm hanging up," he said.

"Don't do that. I need you to come with me. I don't want to trust myself to a less competent mechanic."

"I got things to do. I have to do 'em. This isn't something I can put off."

"I understand, sir. Try and understand my position. It is similar to wanting the best surgeon available to massage your heart muscle, even if the second best surgeon is very nearly as good as the best. The consequences of error can be very great."

He was comfortable, but he was scared, Hank thought. He respected the man's balls, not to let fear show in

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his voice.

Then he realized how stupid that thought was.

But it didn't make him angry at Babbage, the way he expected it to. It was hard to blame a machine, even a lawyer-machine.

"Your employer has explained your position to me, sir. I have also taken the liberty of doing some research, in hopes of discovering a way to induce you to come with me. I think I have found it."

"I already told Hobart, it isn't the money. The money's great . . . I mean, I would if I could, but I—"

"Will you step into the aircraft and discuss it with me, sir?" Babbage said.

Hank didn't want to. Not because of the tug-of-war with Rowe; he was too tired to care about that, and besides, he'd won. He just didn't want to face the guy and tell him no, again. He wanted to get the job done, right, and go home to bed. Better yet, he could bunk at the airport.

Then tonight he'd see about patching things up with Megan. He didn't have any idea how he was going to do that.

So he sighed, and was about to tell Babbage he was too busy, when he saw his own black station wagon pull up to the loading entrance.

Megan's red hair showed above the steering wheel. And she'd brought the boys.

And the first thing that went through Hank Schram's mind, as he stood there burning with fatigue, was:

How in the hell did Babbage get my wife to come down here?

But he'd been having a lot of stupid ideas today.

He had said too much to Babbage. He didn't know why he did that. It bothered him not to know why he did things.

But he knew exactly why he bounded up the short ladder into the tail section of the 757, back where the bulk of the wing stood between him and his wife:

Hank Schram was not used to hating himself.

"Awright, Babbage, on your feet. Let's . . . uh, strike that," Hank said.

"Consider it stricken," Babbage said. "Can I help you?"

"Yeah." He had to take a breath to go on. He was almost on his knees, squatting in front of Babbage's microphone outlet. It hurt to maintain the tension in his calves, but he was damned if he was going to kneel.

"Yeah, you can help all of us. Just take all this crap I attached to you and get on a cargo plane. You can get one for less than what all eighteen first-class seats on this baby cost. I checked."

"Actually, Mr. Schram, a cargo slot of my dimensions is slightly more expensive than—"

"Awright, I didn't check! I didn't have *time,* because I'm spending my whole day and night rigging *you* out to play tourist when there's a much easier solution right next door for a couple more bucks."

Babbage had kept right on speaking when Hank interrupted him, but in that same soft voice. Hank had no idea what he said. Now Babbage went on:

"But the cargo plane won't do, Mr. Schram."

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"I'll put in the extra bucks myself. I'm not a lawyer; I get my hands dirty for a living. But I want you outta here, outta my life, and I mean now."

Babbage paused. Then:

"It isn't the money," he said. "I don't make all that much after paying for maintenance, you know. I need to ride in a passenger plane because I am a passenger."

"You're *cargo*, too," Hank said. "Same difference."

"It's *not*. I have to be a passenger, just like anybody else. You wouldn't put a blind man in a box and ship him as cargo, would you?"

Hank blinked. "No."

"Would you ship a person in a wheelchair, or a deaf-mute, like they were so much scrap paper? How about a black man, or a woman, or a Jew? Are they people or are they cargo?"

"Hold on a minute—what kinda Nazi crap is this? Jews, blacks—what do they have to do with shipping cargo?"

But Hank had a feeling he knew.

"Once, they weren't human beings, either," Babbage said softly. "Oh, I grant you they were human in every sense that counted, except in the eyes of the law. In the eyes of the law, they were property. Objects.

"Cargo."

Hank pursed his lips. He was starting to feel like a jerk again.

"Nobody's saying you're not human, Babbage. I mean, you know—a legal person. Whatever. It doesn't make any difference how you get to Dallas, right? The important thing is, you're there."

"But that's the whole point of this hearing, Mr. Schram. I'm a person in law because of a ruling last year in Cook County. My practice of law, my ability to own property, even to control my own location and function—it all hinges on that one decision by an elected judge. Now the state supreme court of Texas has a motion before it to declare me the property of Austin-Sys, my purchaser. My freedom is at risk."

Hank blew out a sigh. He was still mad at Babbage—would be for some time, probably. He'd put Hank in a hell of a bind back home.

"Can't you get a, whaddyacallit, contingency?"

"I have tried. But I'm not actually a party to the suit. The defendant is Model Business Machines, my manufacturer. I filed an amicus brief, but honestly, Model isn't in much danger. If I'm a person, people will want a Model 2600 to be their lawyer, or their companion. If I'm not, corporations can go back to buying 2600s to run their e-mail."

"Not as much danger as you, you mean."

"That is true. Everything I do is being scrutinized as ammunition for one side or the other. So if I fly—and I must fly to get there on time—I must fly the way people do."

Hank blew a breath through his nostrils. He stood up.

"OK. I'll do what I can for you. You'll get there on time. But I'm gonna need a little personal time too. My wife's been calling, and—"

Babbage emitted an electronic squeal.

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"—What the?" Hank said.

"I needed to interrupt you," Babbage said. "I may be able to help with your wife. She is on the way here—"

"She's here, buddy. In the flesh. And she brought the—hey. How'd *you* know?"

"I asked her to come."

"You—" Hank choked on words colliding with each other.

"I thought that since your son's birthday was today, and you had no time to celebrate with him, you might hold your party in the first-class cabin on our way to Dallas."

Hank squinted. It all made sense, but—!

"You're serious," he said.

"If you're willing," Babbage said.

Hank shook his head. He'd heard just about everything now.

"Babbage," he said, then started again.

"*Mister* Babbage, you are one hell of a sharp cookie, so help me Jesus."

"Would you say so in a court of law?"

"Hm. Seems I'll be in Dallas tomorrow one way or the other."

"I do try."

"I got *two* boys, y'know. Think there'll be room up here?"

"There will be several seats available, even counting my support machinery. And after all, I don't want any paying passengers complaining about sharing space with a machine."

"Thought you said you were a person."

"I am. You're a human person, I'm a machine person. Same difference."

JUDGE WRIGHT: Ms. Berrendt, anything more from this witness?

JANE BERRENDT: Mr. Schram, you may stand down.

HENRY SCHRAM: You hang tough, Ben. We'll get you out of this, awright?

JANE BERRENDT: Stand down, Mr. Schram.

ARWIN LEBANC: Your Honor, the defense rests. ■

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Sherry Briggs

THE ARTIFACT

Future publishing will change a lot, but one principle of What It Takes will remain the same. . . .

Lasar Tarrell was not a happy man. As he sat in the head office of Galacticon Publishing, Inc., he stared glumly through the window giving him a view of the humming activity, and brooded. A thick, black cigar was clamped between his teeth, enfuming the office thoroughly with thick, foul-smelling smoke. Nobody ever complained, however. All of the whirr was completely mechanical. A millennium ago this place would have been a hotbed of torn hair, small intrigues, cigarette stubs, budding romances, gripes about the boss, harried editorial assistants munching their way through the ever-present slush pile, worry about deadlines. . . . As Tarrell surveyed the smoothly functioning office, he thought how much things had been improved since the Terran Collapse and subsequent Galactic Amalgamation.

Of course he missed having nobody to chew out except his placid Editor in Chief, sole other human occupant of the office, but that wasn't the real problem. The slush pile was bigger than ever, but it had lost its old savor. The usage and grammar were invariably polished, and there was a distinct lack of silly spelling errors. All manuscripts were flawlessly formatted and printed, submitted on discs which Tarrell simply fed into his own computer for preliminary screening. Nobody ever sent in a ragged pile of yellow lined sheets written by hand. Tarrell, in fact, had never heard of either pencil or pen.

Long ago, when computer first met typewriter, the result had been dubbed the word processor by some prophetic genius. This new creation lived up to its name. It allowed writers to write, re-write, edit, add, delete, polish, and eventually print out their masterpieces. A spelling checker was added, and later made automatic. Au-

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thors made prematurely bald by desperate head-scratching over synonyms that refused to come had a computerized thesaurus to aid them. This had expanded to include several thousand phrases and, like the spelling checker, had become automatic. Grammatical aids had likewise been built into the increasingly wonderful machines, with the result that awkward sentence structure, with overly punctuated, convoluted (though often somewhat surprising), and hard-on-the-eyes sentences, along with a whole host of mixed metaphors, vague allusions like vaguely floating clouds, dangling participles and sentences ending in prepositions became something no longer heard of. Sadly, somewhere along the way, the spark had been lost.

On publication day, the Galaxy was filled with subspace signals flashing under space between the stars to Galacticon's planetary receiving stations. As the encoded signals arrived from Earth, the smooth whirring of well-kept machinery commenced on thousands of worlds, leading to neatly wrapped piles of periodicals mechanically decanted at all distribution points. Galacticon Publications put out a slick, highly colored, holographically illustrated periodical, much too elegant to be a mere magazine.

To add to the wonder, it was cheap. Still, Tarrell had the uneasy suspicion that low price was all that kept his magazine in circulation. The multispecies Galactic Federation was spreading, but growth in sales was minimal. The bottom line was that Terran authors were producing technically flawless creations, but the raw element of creative surprise was lacking. The rest of the Galaxy was not excited.

As Tarrell gloomily pondered the threatening second derivative in the sales figures his door burst open. Tarrell's sigh, pinched lips, and slightly narrowed eyes fell rather flat. Not only was their intended target oblivious, but the rest of the picture Tarrell presented didn't fit. He had been so surprised at the sudden intrusion that he had gone about a foot vertically, as the cigar had shot roughly horizontally. After brushing cigar ash off of his vest, nipping a wastebasket conflagration in the bud, and locating the actual cigar under the desk, where it had skittered after ricocheting from the wall, Tarrell faced the only other human working in the huge complex with an expression of long-suffering patience practiced in private for years.

Daigle Freelander was not the sort of assistant to give a boss much chance to show off a long-suffering expression. He seemed like a professor with his lanky frame, preference for tweedy jackets and habit of communing silently with his pipe for a while before delivering himself of an opinion. His work had been efficient, and he had not made a practice of dashing dramatically into his superior's office, accounting for Tarrell's lack of practice in long-suffering. The two men faced each other over the wreckage for a few seconds, then Tarrell inquired gruffly, "Well?"

Wordlessly, Freelander handed him a manuscript. It was yellow, dog-eared, dirty, and illegible. Smudges al-

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ternated with blotches which could have been, and probably were, peanut butter and mustard. Pages were ripped and taped back together. Tarrell, wondering where Freelander had found such an object, stared at it in disbelief. The old slush pile had been gone through centuries ago and the often regrettable contents long since dispatched hastily back to the hopeful originators or their descendants.

"Something out of some pre-Collapse back corner?" asked Tarrell, who had read of the horrors of the old slush pile.

"No," Freelander answered. "The author's in my office."

Tarrell knew what he had to do next. He sat down and read—heavy going. Moving his lips, spelling out words, and backtracking with endless patience, he slogged through the barely legible pages. As he labored his eyes began to glitter, and a vein in his neck to pulse visibly. A half hour later he put it down, still only partly finished, and looked in awe at Freelander.

"My God! Where did he get his machine??"

"I don't know." replied Freelander. "He just said to take a look, and if we considered it publishable, he'd try to see if he could clean it up a little."

"First, I'm going to talk to him about that machine of his." Suiting the action to his words, Tarrell lunged hugely through the door to his office, and proceeded with surprising swiftness down the corridor.

Tarrell had been practicing his Grand Entrance for at least as long as he had his Long Suffering Look, and he used it now. His portly frame loomed in the doorway, temporarily casting a shadow on the hopeful author. On first sight, the author of the story that had so electrified the entire human work force of Galacticon Publications didn't seem particularly prepossessing. He was one of the rare non-robots who worked at construction sites, fixing and adjusting the numerous construction robots. Grease was still evident under his fingernails as well as in the creases of his hands, although they were scrubbed nearly raw. His face had the slightly scuffed appearance of someone who has just shaven off a growth of hair which simply accumulated out of neglect rather than a desire for a beard. The suit he wore was out of fashion, wrinkled, and worn in spots. His eyes, however, drew Tarrell's attention at once. Lively and intelligent, they twinkled with good humor.

Tapping the manuscript in his hand, Tarrell began.

"Mr. Jeppard," he said, hoping that he had managed to decipher the scrawl on the title page, "Have you ever written anything before?"

"Oh, no, sir! It wasn't till this latest construction site that I wrote anything at all!"

Jeppard's shining eyes seemed to beg to pour forth his whole story, probably starting with the "Baby's First 'Puter" that he had as a child. It was obvious, however, that he had the good sense merely to tremble on the brink of further revelations, and not plunge on.

"Oh, I see," said Tarrell, not quite

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seeing. "So this is your first effort, then."

"Yessir. If you think I need more practice, I'll just be on my way. I know you are busy men, and it was probably silly of me to show you my very first thing." He reached for his manuscript as he spoke, but Tarrell held it close, and let loose a barrage of "harrumphs" from the back of his throat.

This throat-clearing exercise was another of Tarrell's treasured but seldom actually used Perfect Boss effects, and the results were striking. Jeppard leapt like a startled deer, and turned pale. Tarrell became soothing.

"Oh, no, Mr. Jeppard. I didn't mean to give you that idea. I would just like to study your manuscript for a little longer, if I may. I see some possibilities here. Of course, parts will have to be reworked considerably, and the story line cleaned up, and so forth but, yes, we may have a place for your story. By the way," he added in an attempt at a casual afterthought, "where did you get your word processor??"

Jeppard blinked, his face glowing.

"My . . . my word processor, sir?"

"Yes, your word processor. The thing you used to write your story."

"Oh, that was what I was going to tell you, but I didn't want you to think I was going on. You see, I found it at the site."

"Is it a big machine?" Tarrell asked, remembering that some of the early word processing equipment had been quite bulky.

"Oh, no, not at all. It isn't really a machine at all. It's a sort of stick, and it makes marks. I have to cut down the end from time to time."

Fascinated, the two most important Terrans in science fiction publishing stared at the small object which Jeppard drew from his pocket. It was bright yellow and pointed on one end, with something black and greasily shiny at the point. The other end was flat, with a ridged ring of brass striped with the scratched, fading remnants of black paint. The words EBERHARD-FABER MONGOL 482 were printed by some ancient process, likewise in black, on one of the sides of the yellow stick, which was hexagonal in cross-section. A Numeral 2 appeared as yellow in a black lozenge, at right angles to the other letters and numbers. The men stared at it for a long time, and then back at the battered, vibrant manuscript in Tarrell's hand.

"I can't tell you just exactly how it works, sir. I just picked it up, and pretty soon I was writing a few words, tracing the letters my pocket jotter prints and . . . Well, you see what happened."

Freelander pulled for a long time on his pipe, exhaling at last a long, fragrant cloud of smoke. Finally, he voiced an opinion. "Well, there is a lot of information we have lost about civilization before the Collapse. They probably had technology of which we cannot even begin to dream." ■

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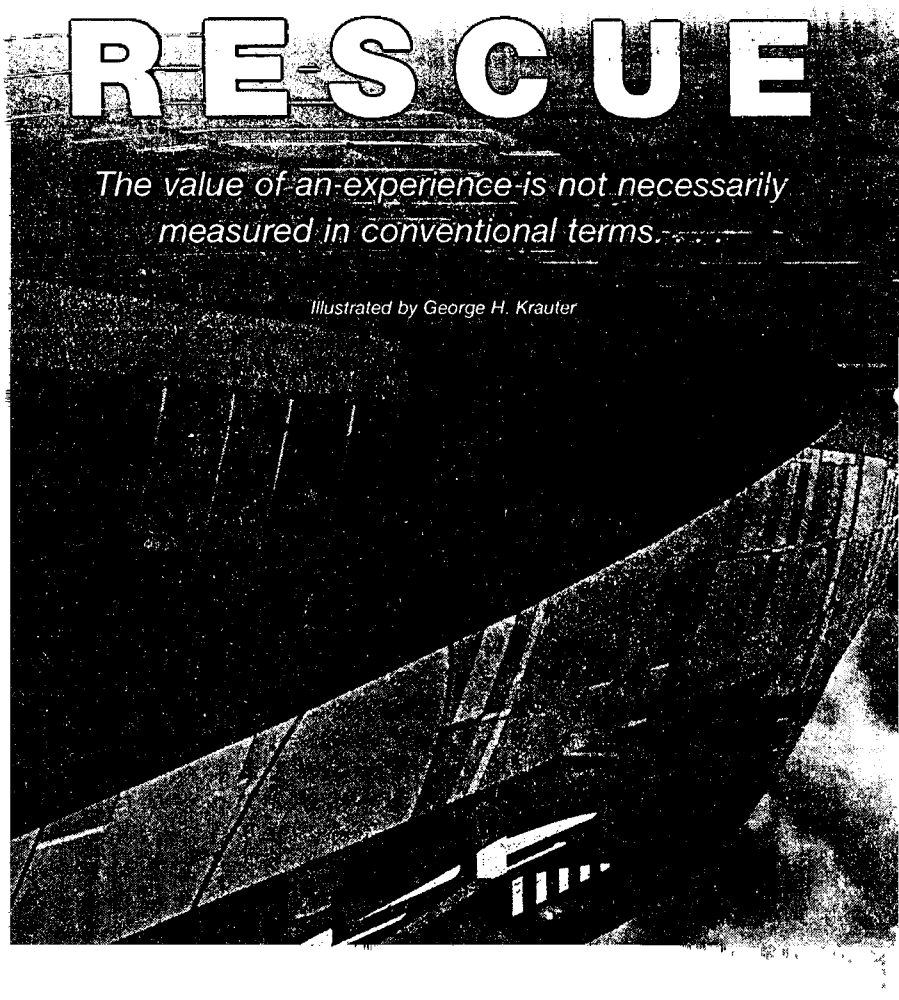
Bud Sparhawk

PRIMROSE RESCUE

The value of an experience is not necessarily measured in conventional terms.

Illustrated by George H. Krauter



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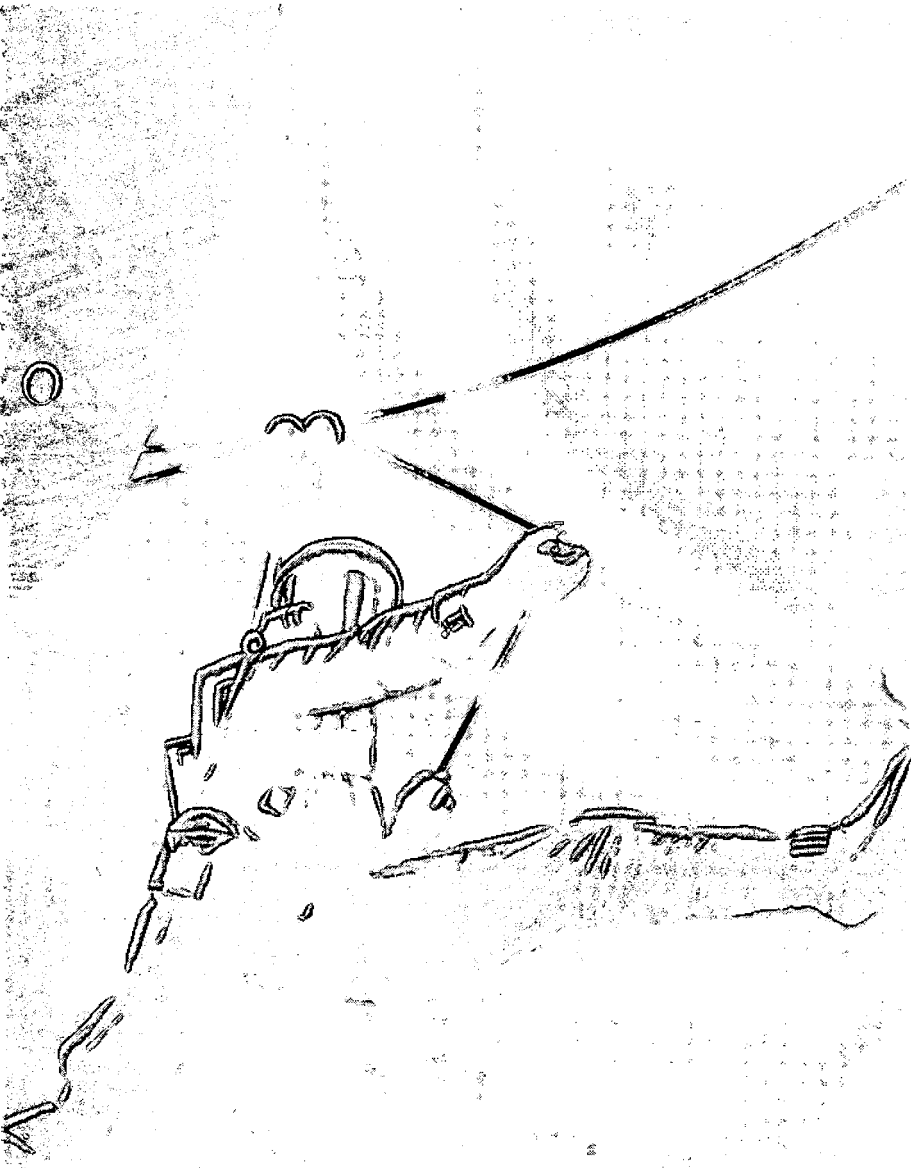

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"Let her have her head! Stop fighting her," Rams raged at the big woman as she struggled with the wheel. He lifted himself to one elbow on the low bunk.

"What the hell do you think I'm doing," Louella shot back. "You try steering this damn overgrown tub with one arm and see how easy it is!" She lifted her sling to emphasize her words.

"Let me get over there. . . ," Rams said weakly as he tried to push himself up and failed. He flopped back onto the pallet that Pascal, Louella's navigator, had rigged for him.

"Don't bother trying to get up. You'd fall right on your ugly face even if you ever did manage to get your ass in gear," Louella said nastily. "With that smashed leg you probably couldn't make it to the pilot's seat, even if you weren't so doped up. Now, be quiet and let me concentrate; I've gotten ships home in worse weather than this. Trust me: I know what I'm doing!"

The *Primrose* was a huge whale of a vessel, its crew quarters were nestled deep within a bulbous pressure hull. Beneath it hung a kilometer-long diamond fibre keel and on her upper deck were the enormously strong sails that harnessed the howling winds of Jupiter. Lashed securely to her side was a smaller ship, *Thorn*; a barque that, until recently, had been JBI's sole entry into the Great Jupiter Race. It was this tow that made handling of *Primrose* so difficult.

Rams was still struggling weakly when Pascal arrived with three mugs of steaming tea. He placed one mug where Rams could reach it and held out another cup for Louella. "If you want to drink this you'll have to let me take the wheel. You've only got one arm."

"Don't wreck my ship," Rams mumbled as he fumbled with the spill-proof cup, trying to put the nipple to his lips.

"Fifteen years of handling large sail, Captain. I think I can keep her on track while Louella sips her tea," Pascal replied affably. "Now drink yours. It will make you feel better."

"Sure, long as she didn't make it," Rams grumbled. During Rams's infrequent conscious periods he always complained about the food. Of course, on that matter, Pascal could only agree. The one skill that neither of them had mastered in all of their years of ocean racing was cooking. On their two-person races they'd usually eaten pre-packaged food, which required no cooking and could be eaten wherever and whenever necessary. His own mastery of the culinary arts was limited strictly to a properly brewed "cuppa tea" and the boiled or microwaved pouch of whatevers when he had the time.

He couldn't understand this ship's advanced food preparation technology. No matter what he did, the best he could turn out were slabs of tasteless, tough, and practically indigestible generic foodstuffs (the package *said* it was meat, but he still wasn't sure about that—it tasted too much of wood pulp to come from an animal). Foolproof, that's what the instructions said; absolutely foolproof. Ha!

The only thing that was worse than

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his attempts at cooking were Louella's cinders of burned organic matter—offerings, no doubt, to her unknown teacher in the culinary arts.

A week earlier Pascal had given Rams pain blockers for his smashed and broken leg. He had administered as much emergency treatment as he could with the limited medical supplies he had found within *Primrose,* using medical skills that had been acquired in his years of ocean racing, when competent medical help for an emergency was, more often than not, hundreds of miles away.

He'd stabilized Rams, stanched the bleeding, evacuated the wound to prevent infection, and splinted the broken leg to prevent any further damage from inadvertent movement. More extensive treatment than that required a well-equipped medical center and trained staff who knew more than he, and that meant that they had to find their way to a station soon, before they ran out of painkillers.

The Great Jupiter Race had started out so well, a sailing concept of intense interest on the part of sailing enthusiasts throughout the Solar System. Although the great sailing vessels of Jupiter had been plying the endless red seas of Jupiter's atmosphere for decades, it was only the race sponsored by the corporate giants that turned atmospheric sailing on the giant planet into a sport.

Jerome Blacker, head of JBI industries and one of the men who built the Jovian industrial empire, had sent his best captain and navigator, a team that had won most corporate races on Earth's seas, to win the Great Jovian for the corporation. Not only would the race provide a way to use the JBI funds the Jovians had tied up in their banks, but it would provide an opportunity for unmatched publicity.

But the hurricanes and typhoons that Louella and Pascal had faced on Earth's tiny oceans were nothing in comparison with the swirling monsters that spun out of Jupiter's great heat engine. Eight days out of the start their barque, *Thorn,* had been hit by a monstrous hurricane that left them helpless and floundering in the great dark.

By sheer good fortune *Primrose,* the sailing ship they were now on, had managed to rescue them, although at great cost to Rams, *Primrose*'s captain, who broke his leg while trying to save them.

Rams's ship, like every sailing vessel on Jupiter, held a complete data base of every station. The data bank's information allowed the ships to venture into the fierce winds of the giant planet with assurance that they could reach their destination. The inertial continually calculated each station's relative bearing.

According to the inertial they had been several hundred hours north and west of the nearest floating station when Rams had rescued them. Since they came on board they had been steering as tight a course as they could to intercept that station's projected track.

Pascal knew that each station was stabilized to stay at a particular latitude. They maintained their track by

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manipulating huge drogues—bucket-like sea anchors—to maintain a constant and predictable velocity as they were blown along the belts by the winds of Jupiter. The floating and stationary hub stations were the only stability a sailor had in the maelstrom that raged at this level of the atmosphere.

For the first five days they had hoped to intercept Charlie Sierra Twelve as she followed the steady fifteen meter per second track in the data bank. Now it appeared that they would not intercept it as planned. They were falling farther and farther behind with each passing hour.

Primrose lumbered heavily with *Thorn* under tow: Louella could only bring her to within sixty degrees of the wind. What made it even more difficult to keep to the schedule they had set was that *Primrose* showed a definite tendency to try to turn downwind every time attention flagged. As a result they were moving slower than planned. According to Rams's careful calculations they would miss the station by two days, and possibly more. So close and yet so far. It was frustrating.

Pascal and Louella constantly fought the ship's desire to reach. If she did so they would slow to wind speed. Such a turn could easily spell disaster. With *Thorn* tied to *Primrose*'s side the force of the wind could easily smash the two ships against one another and cause extensive damage to both.

It wouldn't take much damage to an outer pressure envelope to send them to their doom in the endless drop below. A rupture of either ship would drag the other down.

So they had to fight the weather and their own ship. They had to hold to a line that held a possibility of finding refuge and aid. They had to try for the next station in line.

Pascal was worried about Rams's condition. The captain hadn't taken well to his medication and had remained unconscious most of the time. Could he have calculated a wrong dosage? Suspecting that he had done so, he reduced the dose. As a result Rams stayed awake but was in constant, low-level pain. They *had* to get him to a decent medical facility soon. Without his intervention *Thorn* might have become a twenty-first-century *Flying Dutchman,* sailing Jupiter's vast seas with the ghostly crew of Louella and himself. He owed this man a lot for saving him from spending eternity as Louella's constant companion, and *that* required far more gratitude than he could ever express.

After carefully reviewing the data bank of possible destinations Pascal selected station CS-17 as their next most likely target. After a few minutes of intense calculation he predicted that they would intersect her track just eight hours ahead of her, five days, fifteen watches, hence.

That meant that once they got in front of her, all they had to do was simply reduce sail, slow below wind speed, and wait for the station to creep up behind them. It was a simple plan, and one that wouldn't require special handling.

Twenty hours before they arrived at CS-17's track the radar alarm hooted loudly, bringing Pascal to high alert

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and Louella staggering sluggishly from her cabin, her broken arm forcing her to move carefully down the passageway. In the past few days she'd banged it often enough to learn the painful lesson of keeping it held closely to her chest. Even the drugged Rams was awakened by the clamor.

"What the hell is that?" Pascal exclaimed, pointing at an indistinct shadow on the screens. "Louella, see if you can crank up the gain." He fought to keep the image centered in the screen by manipulating the sail controls and the wheel.

"Don't touch . . . gain," Rams wheezed from his pallet. "Too much noise out here. You'll wipe out whatever . . . we have. Try infrared instead. Maybe you can get a better picture with that."

"Can't, it's too far away to use the IR—and the damn sonar doesn't help either! Oh no, there it goes. . . ."

Louella reached Rams's side just as the hazy shape disappeared completely into the sparkle of background noise. "What was that—what did we just miss?"

Pascal scowled at her. "You should be sleeping, not up here in the cockpit."

"Can't sleep with that stupid alarm clanging," she shot back, her weariness evident in the lack of conviction in her voice. "What did you see?"

Pascal described the faint image that had raced across the radar screen and his inability to resolve the image into anything he could comprehend. "If we had some decent equipment . . ." he began.

"*Primrose* has . . . best equipment on . . . planet," Rams mumbled from his bunk. "Cost . . . a bloody damn fortune. But can't run a tight schedule . . . without it. Won't find better gear on any ship on the planet," he finished in a rush.

"Then why couldn't we see what that thing was?" Pascal demanded, angry with frustration and the lack of rest that kept him from concentrating.

"Environment's the problem," Rams explained. "Old man Jupe puts out . . . lot of radio noise—magnetic field or something. Too much noise for radar, even with the double encrypted digital radar I use. Best I can 'see' is 'bout a klick."

"Which must have been just about the distance of that thing we passed," Pascal said, shaking his head to clear it.

Louella was still scowling at the instrument panel. "One kilometer for radar and the double damned infrared's only good for close range work; about a hundred meters or less. Since the docking sonar is only good for five hundred meters or so it's like sailing blind on a dark night in the fog!"

"Gotta depend on your inertial," Rams said with a whisper of finality.

"You heard the man: Depend on the inertial," Louella repeated as she staggered back down the passageway. "Wake me when it's my turn at the wheel."

"So what *was* that thing we saw?" Pascal asked doggedly as she left. "Was something really there or was it just a radio ghost?"

"Don't know," Rams replied softly, his voice fading as he fell back to his

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drugged sleep. "Out here you . . . trust your inertial. You gotta trust . . . data."

The next day the inertial indicated that they had arrived on the track of CS-17 and were leading it by nearly six hours.

Louella started sailing a waiting pattern, criss-crossing CS-17's predicted track while heading the ship in the same direction as the station. Pascal anxiously scanned the three sensor screens for the station's arrival each time they crossed her predicted track.

After ten hours of anticipation CS-17 still hadn't arrived. According to the inertial's readings the station should have been right on top of their position, yet both the radar and sonar showed nothing there except clear seas, roaring winds, and the perpetual hiss and crackle of radio noise at the limits of their range.

"Trust your inertial," Pascal muttered angrily under his breath each time they crossed the empty track.

"If the station isn't here then where could it be?" Louella demanded when she took over the watch. She was as frustrated as he at the lack of contact after nearly a day had passed. "Could the station master have altered the station's course for some reason—to avoid the storm or run a rescue mission?"

Rams grimaced with the pain in his leg. They needed him conscious and alert for this discussion, so Pascal hadn't administered the scheduled shot of sedative.

"The stations' positions are the only stability we have down here." Rams said through clenched teeth. "It's only the absolute predictability that makes sailing possible. No station master would ever vary his track by a millimeter, even if his life depended on it, because every sailor is dependent on that station being *exactly* where he is supposed to be at all times. No, the station wouldn't have deviated from the track for any reason."

"Then something must have happened to it," Pascal said slowly. "Maybe the storm moved it to a different track. Hmm, with that much wind force almost anything could be possible."

Louella snapped her fingers. "That's it! I'll just bet that's the ghost you nearly ran into earlier—we must have passed the station without realizing it." She turned to Rams. "Is there any possibility that your inertial equipment is out of kilter; that somehow it is giving us the wrong readings?"

Rams shook his head weakly from side to side, obviously trying to clear his head. "Not possible. The inertial has a better pedigree than the King of England. Remember, I'm staking my life on it every time I set sail. I calibrate it with the station's master system before I leave port. No, it can't be wrong—just not possible."

"Then, somehow the damnable storm must have moved the station off course, off track, whatever, and that's why it isn't where it's supposed to be."

"Brilliant deduction, Louella," Pascal injected. "But what can we *do* about it. Should we try to catch up to it?"

"Can't do that. Don't know what track she's following. Haven't a prayer of finding her." Rams took a deep

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breath before continuing. "If the storm blew the station off her track, then the master's probably fighting like mad. He has to get her back on track: probably working the sea anchors, ballast tanks, whatever to move her. Even if we use her last position we can't predict the line he'll take. Take more than dumb luck to find her. We'd never know how far below or above her track she'd be."

Louella sighed and made a small adjustment to the tiller. "So what do you suggest that we do?"

"Simple," Rams smiled groggily as he climbed out of the pilot's seat and stumbled toward his bunk and some much needed rest. "Find 'nother station."

By the end of his next watch Louella had decided on the station that they could intercept soonest and set them on the intercept track. The station she chose, CS-12, was farther to the south and an eighth of the way around the planet, far enough from the track of the storm not to have been affected. With proper trim and a little luck they could transit the distance to her track in little over a week or, with fair winds and some luck, a little less.

"We won't starve before we get there," Pascal remarked when he saw her sail plan. "I think we have enough food and water on board to last us. Just the same, I'm worried about our host. Rams's leg is definitely looking worse and the amount of sedative I've got left in the medicine chest is running dangerously low. We have to get him to a doctor as soon as possible."

"I agree. Be a pity to lose him after he rescued us. Say, our air looks good, too," Louella said squinting at the telltales on the instrument panel. "We've enough reserves to spend another two weeks out here before the atmosphere in here goes stale on us. As long as we don't run into any more problems we shouldn't have any trouble reaching CS-12. Piece of cake."

"Sure," Pascal replied with a worried glance at their rescuer. "Let's just hope we *all* survive long enough to eat it."

The following days were an endless blur of watches at the wheel, trying to keep *Primrose* on her track and squeezing every bit of speed they could out of the ship. Pascal took to talking to Rams in the long quiet hours to keep himself awake, telling the captain of the races he had run, talking about the lean years before being hired by JBI when he and Louella had bummed around the world, their clothes their only possessions. He spoke of the clear air of a winter's crossing, the stormy clouds of a southern storm, the crystalline brilliance of a spring night far from land, and the smooth hissing silence as a ship's bow sliced the waves.

The one thing he never spoke about was the gut-wrenching fear he had felt when he brought Rams back to *Primrose,* and the shame that still burned inside him for his craven, cowardly behavior. Louella might think he was some sort of hero, but he knew the truth of what had happened, he knew absolutely certainly that he was, at heart, a sniveling little coward, afraid of the deep dark that was anxious to pull him to its bosom.

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The return to his bunk at the end of each watch was a brief respite, a welcome relief for his poor body. He could hardly wait to lay down and release the truss that bound his lower body and protected him from rupturing himself in Jupiter's constant two *g* drag. Usually he fell asleep in seconds, only to groggily wake at the chime to return to the wheel and relieve Louella.

But occasionally he could not rest. In those periods he recalled the terror he had felt when he was outside. What if Louella found out that his cowardly fear had nearly caused him to kill himself and the captain? Would she laugh at him, belittling him in that taunting way of hers if he told her? Yes, he thought sadly, she would do exactly that. He had no choice but to hide his cowardice from her and Rams. He just wished that he could hide it from himself as well.

He had nightmares of falling endlessly into Jupiter's bottomless depths and being crushed slowly in her enormous embrace. There was no rest from such dreams and he usually awoke bathed in the stink of fearful sweat.

Ten days after the near encounter with the wayward station, the winds, which had been generally westward, suddenly became gusty, shifting thirty degrees to the north, varying in strength each time they quartered back to the west.

Once, *Thorn* started to drift away from *Primrose* when the winds gusted, only to slam back and strike broadside as the wind shifted. *Primrose* shuddered with the force of the collision. A moment later, far below, *Thorn*'s keel, with the huge rock attached, smashed into *Primrose*'s and sent a vibration racing upwards that made the hull ring.

The chunk of rock embedded in *Thorn*'s keel had been a gift from the storm, one of the valuable bits of flotsam the storms occasionally brought up from the depths. It was these rocks that made Jupiter's miners risk searching the edges of the hurricanes despite the dangers. A single rock could bring a fortune for its metallic content, and a modest profit for the volatiles that it might contain. By the standards of the trade the one caught in *Thorn*'s keel was enormous, ten times the size of the largest one Rams had ever heard of.

"Any more surprises like that and we're liable to flounder," Louella remarked as the vibrations dampened. "I'm not sure of how much punishment this ship will bear."

"We ought to cast *Thorn* off," Pascal suggested. "*Thorn* and that damned rock's a danger to us. Besides, we could make better time if we weren't burdened by the tow."

"NO!" Rams shouted from his bunk. The reduction of the dosage meant that he was conscious more than not. "Can't do that to me . . . won't let you steal my future."

Pascal knelt beside him. "Captain, be reasonable. You need medical attention soon or you'll never be able to use that leg. What good would all the money be if you can't walk?"

Rams coughed. "Not 'bout money . . .'s about freedom: owning my ship free and clear; being able to steer

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from port to port without worrying about the bank waiting to seize it. About having enough profit to get a decent crew, 'nough to put something aside for when I can't fight the damned gravity any more."

He pushed Pascal's arm away and turned his head toward Louella, stretching a hand out to her. "This is about having *Primrose* as my own for the first time. Can't you understand that?" he sobbed before lapsing back to unconsciousness. "Can't . . . you . . . . understand. . . ?"

Pascal couldn't understand Rams's concern. He'd always sailed on someone else's boat; sometimes as captain, but mostly as crew. Ownership had never mattered to him; it was being able to sail the ship, to direct her course, to trim her heading was all he cared about. There always had been far more ships needing trained captains and crew than there were capable people. Ownership wasn't important.

"I understand," Louella remarked unexpectedly from the passageway, breaking his chain of thought. "We'll do everything we can to save her, won't we, Pascal?" The tone of her voice told him that anything other than agreement would create a hell of a row.

"It's insane," he replied with as much emphasis as he could muster as he let her slip behind the wheel. "We're liable to have a hull rupture if *Thorn* smashes into us again! We'll never make it to the station unless we cut the damn tow loose and get rid of *Thorn* and that damned rock! It's stupidity to try to save them when our own survival is at stake."

Louella snorted in derision and twisted the wheel, heading *Primrose* back into the wind. *Thorn* was pushed away as the headwind rushed between the two hulls.

"I'm putting us on a new course. If we sail close to the wind *Thorn* will stay on our lee side and away from *Primrose*. We won't have any more bumping."

"That's crazy. That is completely off our planned course! We might miss the station entirely!"

"Pascal, you bitched the same way when we were trying to work our way around Cape Horn in that storm back in '79, and I got us through that, didn't I? Now, instead of complaining, why don't you try to figure out what this new course will do to our arrival time."

After a few minutes of playing with the inertial and the computer Pascal announced that they would arrive too late, twenty hours behind the station.

Louella considered for a few minutes. "If we come up behind her then we can go on a broad reach and catch up to the station. Hey, our speed has to be faster than the station. We can catch it in maybe thirty hours or so. That'll only add another day or so to what we originally thought. Close enough, and it saves the tow for the captain." She nodded toward Rams, who had slipped back to sleep while they argued. "That should be good enough reward for saving our skins, eh, Pascal?"

Pascal couldn't argue with that: He just hoped that their supplies would last.

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And the captain, of course.

Rams's condition was getting worse by the hour. Pascal had peeked beneath the bandages, saw the swelling around the break, felt the heat radiating from the wound. Obviously there was an infection present within the leg, probably around the break. He'd been giving Rams the antibiotics until their supply ran out. The supply had never envisioned a journey this long, he thought, and now Rams was paying the penalty.

"We need to get him to a doctor soon," he told Louella when she returned from her all too brief rest. "I think that an infection is setting in and I don't have anything left to deal with it."

"How far away is CS-12? We should be crossing its track this watch, shouldn't we?"

Pascal started, the discovery of Rams's problem had driven the approaching station completely out of his head. That was the trouble with exhaustion, it was so damned hard to keep your mind focused, so hard to remember anything. "Yeah, we should hit it sometime in the next few hours. Then all we have to do is catch up to her."

Louella slipped into the seat and placed her hands wearily on the wheel. "Piece of cake."

"Trust your inertial," Pascal replied mirthlessly with a final glance at Rams. He headed for his bunk and a few blessed hours of relief.

He awoke with a start. An alarm was ringing shrilly somewhere. Was it time to go to school? No, that was the dream. He shook his head to clear it and realized that it was the radar alarm. They must be near the station! "Damn Louella," he cursed. She must have let him sleep right through the watch, doubling her own burden to lighten his own. He tightened the truss, stood and moved toward the cockpit, checking the time as he did so.

Wait a minute; he hadn't been asleep more than four hours! What the hell was happening? The station was still hours away. What could they have run into?

"It's another damn ghost," were the first words Louella spit at him as he entered the cockpit. "Come on over here and see what you can make of the displays."

"Looks like something really big. Could be the station, just like the last one. Trim us up a couple of points higher, would you?" Louella twitched the wheel slightly to turn *Primrose* closer to the wind. Their speed picked up slightly and the radar image started to clear.

"Doesn't look like a station," Pascal announced as the outline clarified. "Come around another ten degrees. Yes, stay on this heading and we'll be able to pick it up on the sonar."

An hour later they still couldn't make out what they were seeing on the screen. The image showed something larger than the ship by a factor of ten, but looking like nothing they'd ever seen.

As best they could make out it was roughly cone-shaped, with the blunt end facing the wind. Whenever they got close a slimmer projection ap-

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peared at the leading end and seemed to lead upwards.

It was Rams who figured it out. "It's a drogue," he explained. "One of the sea anchors the station uses to hold itself in place. They're usually a klick below though."

"What the hell is it doing at this level?" Louella demanded. "I thought those things were hundreds of meters below the stations, not on the level the ships used."

Pascal thought hard. "Maybe we aren't where we're supposed to be. Perhaps we are way down below where our instruments tell us we are."

Louella stared hard at the display, trying to work out her own conclusions. "You think there's something wrong with the altimeter? Oh shit!"

"What's the matter?"

"The altimeter isn't absolute. It just figures out the altitude by the buoyancy of the ship—it's an approximation."

"So we aren't as high as we should be? That doesn't make any sense. If the outside pressure was lower then the station would be as affected as us." Pascal replied, fighting to hold the logic of the problem in his mind.

"*Thorn*'s dragging us down," Rams suggested. "Rock and ship are ballast too. Holding us down."

"Why didn't I think of that," Louella exclaimed. "Crap, all we have to do is rise to their level to dock with her."

With that she reached out and flipped the heater switches that would vaporize and vent a portion of the ballast and lighten the ship. "Shouldn't take more than a few minutes to evacuate some ballast. Hey, that's strange. . . ." Her forehead crinkled in thought as she stared at one of the displays on the console. Finally, she spoke.

"Pascal, honey, I think we have another little problem."

After extensive systems checks, repeated attempts to get *Primrose*'s heaters to work, they concluded that the heater circuits within her keel must be faulty.

Louella said it first. "The question isn't how did it happen; it's what can we do about it? How can we get the ship up to the station's altitude?"

"Need to get down there and fix the circuits," Pascal suggested after a few minutes of intense thought. For some reason he wasn't thinking too clearly, probably because of the lack of rest and the pressure of their predicament.

"I think the drag of the tow is holding our speed below that of the station at this angle of attack. We're losing way relative to the station. We need to quarter away to build up enough to catch it again," Louella said in a tired voice.

So saying, she let the wind take *Primrose* on a slanting course away from the station, building their speed once more. Back and forth they passed under the station, careful to avoid the lines that held the drogues in place, and trying the radio with each pass, but getting only static for their troubles. There was no way they could tell whether the station was aware of their plight or not.

Meanwhile Pascal had crawled forward to loosen the hatch to the lower deck and the heater connections. He

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had to check several times, because he kept forgetting what he had done. As far as he could tell, the heaters were working properly. He could even feel the warmth through the housings with his hand.

So that meant the problem wasn't the heaters, he reasoned slowly. Therefore, it had to be the vents. They must have been damaged whenever *Thorn*'s rock had smashed against their keel. Maybe one of their collisions had warped them into uselessness. No way of telling from down here. Wearily he climbed back up and made his way to the cockpit to tell Louella the sad news.

"I knew we should have cast *Thorn* off when we had the chance," he said once he got his breath back.

"Too late to reconsider that now," she replied, sounding too tired to even argue the point. Instead she appeared to be deep in thought. In a few minutes Louella came up with a truly frightening solution: Pascal would simply go over to *Thorn,* and switch on *her* heaters. That would provide enough lift to bring the both of them to the station's level.

"Maybe I should raise *Thorn*'s sails, too," he suggested dryly. "Or even sail the damned thing up to the station by myself."

The sarcasm was lost on Louella, who was as tired and worn down as he. "Did you forget that we lost the sails, dear? No, just see if you can lighten the load for us."

"Maybe if we just cast off the tow," he began.

"Not after bringing it all this way you won't!" she shot back. "We're going to save both of them!"

Pascal wasn't sure if she meant *Primrose* and Rams or *Thorn* and the rock. Not that it mattered—he still had to go out on deck and dare Jupiter's fatal siren call once more.

He hoped his bowels would hold this time.

Slowly, and with great care, he suited up and returned topside, clipping two safety lines in place as Louella flipped on the lights. Very carefully he worked his way to the edge of *Primrose*'s deck, clamping a deathlike grip on a stanchion to anchor himself in place.

After a few moments in which he tried to steel himself for the task ahead, he looked at the gap between the two ships, the chasm that had no bottom, a chasm into which he could easily fall forever. . . .

No, he shook his head to clear out the thought. He couldn't let the fear control him. He had a job to do. But his guts told him differently, as did his trembling legs.

Thorn was still drifting off to the port side, but she was significantly below the *Primrose*'s level, giving the tow lines a steep downward slope. Why hadn't they noticed that she was pulling them down? Was that something else they had missed because of their fatigue?

Maybe he could do what he had the last time; tie himself to the tow rope and slide down to *Thorn*. It would be easier than before with the slope so steep. Wait, maybe it was too steep; so steep that he would break his legs from the impact of hitting the other

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deck under two gs!

But what if the tow line parted when he hit? With his legs broken he wouldn't be able to hold himself in place—he'd slip over the edge and into the dark chasm that . . .

Damn, why did his thoughts keep returning to *that* nightmare? Once more he tried to clear his head of the nibbling fear even as he threw another line around the winch for added security.

Perhaps he could rig a second line to retard his fall, paying it out as he lowered himself down the line. That would keep him from hitting too hard, but it would also make the time he hung over the deep, black emptiness even longer—increasing the risk of the line breaking and letting him fall, fall. . . . He shook his head, dismissed the thought, and began rigging the lines.

He first put a short loop around the tow rope, then anchored both ends to his suit. He then attached a second loop, and a third, just to make sure. Next, he detached another line, put it around the winch, and secured one end to his belt: That would be his retard line, one he could pay out through his hands and control his slide.

Just as he had before, he said a short prayer before lying down under the tow line and testing the harness he'd created. Satisfied that it would hold him, he released a meter of the security line and felt himself start to slide down *Primrose*'s curving side.

Through the narrow field of his helmet he could only see the tow rope and the spider's web of lines that supported him. He concentrated on letting only a small amount of line at a time through his gloves. With each downward lurch the fear started eating at the edges of his mind, fear that he kept trying to suppress, of the depths that could so easily draw him down, down, down. A shudder of stomach-wrenching fear tore at him as he rocked somewhere above the vast chasm, paralyzed by his fear, unable to move. Tears welled up in his eyes and he felt his sphincter spasm. He was shaking so hard that it was difficult to think.

The longer he stayed here, he finally realized, the greater the chance that the line would break and send him to his death. With great effort he forced his hands to relax for an instant and release another meter of security line so that he could continue his slide toward *Thorn*.

Except he didn't move. The released line drooped limply on his chest. Panic filled him. The retarding line was jammed. He was stuck here! He would stay here forever, dying suspended above Jupiter's crushing depths!

With the desperation of the damned, he reached up to pull at the tow line that was supporting him, desperately hoping to get himself in motion, but the tow line was just out of reach; he had made the harness too long!

And the call of the depths was intensifying, increasing his risk, increasing his fear. The sour smell of urine and emptied bowels inside of his suit told him that his body had submitted to the fear even more than his mind.

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What could he do, he wondered with sudden clarity of mind; just lie here in his own shit and piss and tears until the lines snapped and ended it all? Yes, that could be an appealing option—a few minutes of terror and then the sweet release of death, final and complete! Finally there would be an end to this fear, those nightmares, this cowardice that he had lived with for so long.

But, another part of his mind protested, that would also doom Rams and Louella, two people he had an obligation to save, and one whom he just realized that he loved. He couldn't kill them just because of his own cowardice.

Then he noticed that two of the safety lines were crossed on the tow line. They had jammed while he lay there letting himself submit to the cowardly voice within. All that he had to do was untangle them and he'd be able to continue.

After struggling to reach the lines he finally concluded that there was no way to reach the knot. The only way to undo the tangle was to untie one end of one of them and pull it through. All he had to do was remove one of the safety lines that kept him from falling into the depths at his back.

Did he have the courage to try, or was he too cowardly to take the risk? That was the question. He tried to move one hand toward the line. It froze into immobility, captive of the fear inside, divorced from the urging of his conscious mind. He tried to force his hand to move, to grasp the line and loosen it, but it remained as it was.

At that point he realized that this was an irrational fear, something born in the primal, reptilian depths of his brain. There was nothing he could do about it; his fear wasn't a conscious choice so much as the way his brain was wired. At that it was as if some liberating wave passed through him, releasing him from his false perceptions, releasing his hand from the clasp of his deep-rooted fear.

"Either way I die," he said and quickly, before the fear within could regain control, undid one of the ends at his side.

As the supporting line came loose he fell backwards with a stomach-wrenching lurch. His legs were held as his upper body dropped. The safety line whipped out of his hand and he felt himself fall down, down, down . . . to clang viciously against the deck of *Thorn*.

"I did it! I did it!" he shouted joyously, reveling in his success. He clambered to his feet and looked back at the gap he had crossed. With the sudden feeling of relief he realized that he had crossed more than the physical chasm; he had crossed a threshold within himself. Discovering that he could do what he had to, despite the gnawing, debilitating fear inside of him, meant that he wasn't a coward. A coward would have submitted to the fear and hung out there until the lines parted. No, he wasn't a coward at all, he finally admitted to himself.

And, now that he had conquered the *real* enemy, taming the *Thorn* and bringing them both into dock would be a trivial matter. He headed for the

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hatch and his future, clipping his safety line securely in place with every step. Just because he wasn't a coward didn't mean he should take chances. Jupiter's depths still called to him and the smell inside his suit warned him that the fear was still a gnawing reality.

Thorn seemed terribly cramped when he crawled back inside and made his way to the console. They had left the ship open to the atmosphere so he had to squeeze his suit into the tiny cockpit and the pilot's chair. The switches were widely spaced and he could easily move them with his gloved fingers.

No matter how many times he tried the heater switches the *Thorn* refused to gain any altitude relative to *Primrose*. After the tenth try he remembered that they had lost all of their ballast—that had been one of the problems after that rock slammed into their keel.

Damn, how could he have forgotten something as significant as that? Both Louella and he must be more fogged by fatigue than they thought. Now he really was in a pickle; he had no way to make *Thorn* rise and, worse yet, there was no way for him to get back to *Primrose*. He hadn't the strength to climb up the tow lines in a two *g* field nor, he admitted freely to himself, the nerve.

A quick check of his air supply showed that he had less than a day before it ran out. "Lou, we have another problem," he said into the radio, hoping that she could hear him through the popping, crackling noise.

After she replied, he quickly explained *Thorn*'s status. "As best as I can figure it out," he said slowly, "there's only one way that you two can make it to dock; I have to cut *Thorn* loose and let *Primrose* run free. *Thorn*'s dragging you down: without her weight *Primrose* will be able to make station."

As he said those words he was surprised at his own sincerity. He really was willing to sacrifice himself for them. A great inner peace came over him with the knowledge that he could face his certain death with such calm detachment. Where was the quaking coward who had shit himself on the line? Where was the little man who feared the depths more than his own death? Apparently his cowardice wasn't the only thing he'd lost on the way down.

"You damn fool! That's suicide for you," Louella shot back. "There has to be a better way. Can't you lighten the load? Maybe toss something overboard?"

Pascal replied sarcastically. "Sure, nothing to it. I'll just drag a few tons of metal out the hatch and toss them over the side. Shouldn't take me more than a few months, that is, if I had the equipment."

"At least you haven't lost your sense of humor," Louella responded dryly.

"Yeah, that's one thing I didn't lose on the way down here. Listen Lou, I already thought of that possibility and discounted it. It just won't work." His voice dropped to a more serious tone as he said, very slowly so that there would be no misunderstanding; "Trust me, Louella, this is the only way to save you two."

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"Damn it, Pascal, I can't let you throw away your life," Louella shouted. "Why don't you see if you can cut the keel loose from the housing—better to lose the rock and save you." She paused for a moment and then added, "and the ship, of course."

"Won't work. No tools, no way of squeezing into the lower hold in this suit, besides, there isn't enough time." He explained the condition of his air supply.

Rams's weak voice came on. "Wait a minute. You don't have to cast away. Just lengthen the tow lines. Add more line and see how far the ship sinks. Might be buoyant at a lower level—ain't no P12 layer, y'know."

Pascal considered that suggestion. Perhaps Rams was right; if he rigged all of the line on board to the tow he could gradually let it out until *Thorn* stabilized. Damn, they could have done that from *Primrose* and he wouldn't have had to come across in the first place! Another bitter tribute to their deficient, sleep-deprived thought processes.

But, he continued to reason it out, what if *Thorn* didn't find a level where she was floating? In that case she'd continue to exert the same drag on *Primrose*. Unless *Thorn* floated there was no way that *Primrose* could escape.

But he still had the option of cutting her loose if that didn't work. Wearily he rose from the pilot's chair and began to climb out onto the deck. There was no sense telling either of them that he was considering that possibility, he'd just do it when the time came. As he worked on making the lines fast to the winches he wondered what it would be like to sink into Jupiter's seas. At least, he added with a smile, he wouldn't be falling.

Something loomed out of the dark, whipped beside the ship and disappear into the dark behind him. He'd no more than a brief glimpse of something huge and conical. It almost looked as if some giant bucket had been . . .

He slapped his head, and the helmet rang with the impact of the armored glove hitting the metal. There was no need for them to lose *Thorn* after all! The solution had been in front of them the whole time!

Slowly, knowing that the survival of them all depended on his safety now, he returned to the cockpit and keyed the radio once again.

"You need to cut as close to one of the drogues as you can," he explained to an incredulous Louella. "Get in front of it and let off so that *Thorn* slips inside. With a little bit of luck the drogue will hold *Thorn*. Then I'll cast off *Primrose* so you can get to dock. After that you can have them haul in the drogue."

"Pulling *Thorn* and you to safety," Louella finished for him. "That's freaking brilliant. But do you think I can steer the ships well enough in the dark? I'm as likely to smash you into the drogue as not."

"You're the best helmsman I've ever sailed with," Pascal replied warmly, hoping she could hear the admiration in his voice over the crackling, popping link. "I'd trust you with my life."

"Which you are going to do," she responded without a trace of humor

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in her voice. "Stay off that deck on our approach. You hear me, you little twerp? Stay inside and conserve your air. I don't want to lose you now."

"I hear you, Captain." *Matter of fact, you'll have a hard time getting rid of me from now on,* he added to himself as she cut the connection. There was still a lot of time to wait before he could get out of this stinking suit.

Instead of doing as she wanted, he stood on the deck and peered into the darkness. The lights illuminated the side of *Primrose* and etched the thin tow lines that held the ships together, a thread of light that bisected the chasm he had crossed. For the past two hours he had watched Louella switch the sails, changing the heading to get in front of the station and into position on one of the drogues. When she backed the sails he knew that she had picked up a drogue on her radar and was steering the ships to intercept.

He looked across the stern, wondering when he would be able to see the maw of the approaching bucket and if *Thorn* would hang up on one of the drogue's lines instead. If that happened he'd cast off the lines in an instant to keep *Primrose* from floundering. There was no way he would let her be trapped.

It loomed out of the dark like a great fish, its gaping whale mouth making the *Thorn* a mere minnow in comparison. Pascal didn't hesitate: As soon as he saw the drogue he loosened the tow lines and watched them whip away. *Primrose* shot away, rising like a rocket, its light dwindling into a mere star in the inky blackness above him.

And then even that point of light disappeared as *Thorn* was swallowed by the huge drogue and an absolute darkness descended. Pascal braced himself for the impact when *Thorn* hit the rear of the drogue. He prayed that his safety lines would hold, that he wouldn't be thrown off the deck. He dropped down and held on with both hands while he braced his feet against the traveler bar.

Contact was more like a soft kiss than a harsh crash. There was a slight bump, then a grinding noise as *Thorn* swung around until her broad side rested against the wall of the drogue.

Pascal turned on his light so he could find his way back to the cockpit and noted that the deck was canted at an angle. This puzzled him for a moment until he remembered that the top of the mast was probably touching the low wall of the drogue and forcing the entire ship to one side. They must have come to rest in the very tip of the huge bucket, the very safest place he could be. Now he had only to wait for them to haul their catch up to the station. A piece of cake, as Louella would say.

The young elevator pilot who had delivered them to the station several weeks before smiled in recognition as Pascal and Louella climbed out of the connection tube and eased themselves into their seats.

"Have a good race?" he asked innocently as he readied his elevator for the long trip back up the cable to synchronous orbit where their transport

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back to Earth and Jerome Blacker's wrath awaited.

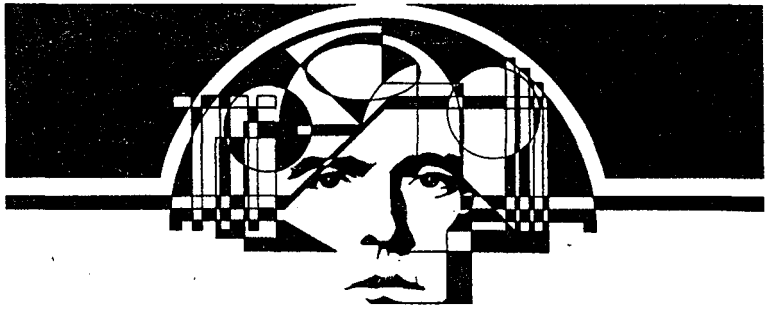
Pascal glanced at Louella, smiled, and answered. "Let's just say that this race was one of our best."

Louella glared at him. "Pascal, you are so full of crap! The only one who came out ahead was Rams, God bless his grasping, greedy heart. Damn it, we lost the frigging race, gave away *Thorn*, cost JBI a bundle, and almost killed ourselves. This race was an unmitigated disaster from the beginning to the end."

Pascal continued to smile at her. Yes, the great Jupiter race had been all of that, and more. But without it he wouldn't have become the man he now knew, and accepted. He reached over, took her hand, and squeezed it gently.

"It was all of that, Louella, and," he added sincerely, "I wouldn't have missed it for the world!" ■

Editor's Note: This is a sequel to "Primrose and Thorn" in the May 1996 issue.



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THE REFERENCE LIBRARY Tom Easton

Fool's War, Sarah Zettel, Warner, $5.99, 416 pp. (ISBN: 446-60293-0).
Frameshift, Robert J. Sawyer, TOR, $23.95, 235 pp. (ISBN: 0-312-863-25X).
Walking the Labyrinth, Lisa Goldstein, TOR, $21.95, 254 pp. (ISBN: 0-312-86175-3).
Fair Peril, Nancy Springer, Avon, $23, 246 pp. (ISBN: 0-380-97345-6).
The Cockatrice Boys, Joan Aiken, TOR, $20.95, 221 pp. (ISBN: 0-312-86056-0).
The Dealings of Daniel Kesserich, Fritz Leiber, TOR, $18.95, 125 pp. (ISBN: 0-312-85408-0).
Jules Verne: An Exploratory Biography, Herbert R. Lottman, St. Martin's, $26.95, 360 +xiv pp. (ISBN: 0-312-14636-1).
Beyond Humanity: CyberEvolution and Future Minds, Gregory S. Paul and Earl D. Cox, Charles River Media (P.O. Box 417, 403 VFW Drive, Rockland, MA 02370), $20.95 (trade paper), 487 + xvi pp. (ISBN: 1-886801-21-5).
Periodic Stars: An Overview of Recent Science Fiction, Tom Easton, Borgo Press, . . .

Back in January, I reviewed Barry B. Longyear's *The Last Enemy* (White Wolf). And if you're a Longyear fan, you rushed right out and—couldn't find it, right?

Sorry, folks. At the time I wrote that review, the book was scheduled to be published in January. Since then, the publisher discovered that a major book chain would order mucho copies—but only if the publisher also brought out the first two books in the series *Last Enemy* concludes.

So. In March, look for *Enemy Mine: The Enemy Papers,* an expanded version of Barry's award-winning novella, including material on the Drac bible, the Talman, and on the making of the movie (of which Barry does not approve). In July, look for the reissue of the neglected *The Tomorrow Testament. Last Enemy* is now scheduled for October.

Good luck, Barry. Maybe White Wolf will decide it wants to reissue that delightful circus series next.

•

Rejoice: Sarah Zettel's second is even better than her first. *Reclamation* dealt with people as machines, one group so ridden by the quest for rule and order that they might as well be machines, another literally engineered to fill machinelike roles, though they have long since gone their own way in quest of freedom. Now Zettel turns

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the tables to consider machines as people.

Fool's War concerns a future when Moslems are trying to live down the blame earned centuries before when a Moslem triggered nuclear war on Earth. Al Shei is a woman who wears the veil and operates a starship, alternating eight months of captaincy with her ne'er-do-well brother-in-law who thinks he can hack top-secret data bases with impunity. She is about to start her turn, transporting vast wads of data hither and yon, and the brother-in-law has supposedly removed all traces of his presence. But there are burned out circuit boards and hints of viruses in the ship's computer system. Meanwhile, one of her crew comes from a group obsessed with the idea that true artificial intelligences can arise in suitably complicated computer systems when those systems capture and reincarnate a human soul. Another crew member knows durned well that artificial intelligences can arise spontaneously, but every time they do they cause catastrophic damage; his own world nearly died from one.

Enter Dobbs, the Fool. Entertainer and psychologist, it is her job to use clowning to keep the crew's morale up. Yet there is something more to her as well; she has a secret agenda, and when the ship makes its first planetfall and delivers its cargo of data, we learn what that agenda is. The data, you see, conceal a rogue AI, violent and chaotic, a thorough planet-wrecker. It must be lured out of the planetary net, reconfined, and delivered to the one place that knows what to do with it.

I can go no further without saying too much. Thus:

—SPOILER WARNING!!—

The great secret is that true AIs arise pretty frequently, all by themselves. Most are never noticed because there is a group that watches out for them, catches them, and hauls them off to be housebroken. This group is the Fools, who are in fact AIs, caught, tamed, and given human bodies. Machines as people, and with quite enough human emotions to feel very, very human to the reader.

Zettel's plot, of course, is something more. There are factions among the Fools. One wishes to pass in secret until real humans grow up and get over the sort of knee-jerk vengefulness that makes life difficult for Zettel's Moslems. The other says, "We're smarter and more powerful than they are. Let's force a confrontation, trash the joint, and show 'em who's boss. They'll come around eventually."

Who wins the argument? I won't spoil that for you, but I will note that every time Zettel's tale looked like it was approaching a suitable climax and resolution, there were still a lot of pages ahead. She hooks you on characters and situation and keeps you reading very effectively. Highly recommended.

Since Robert J. Sawyer's last couple of novels were serialized in these pages, you hardly need me to tell you to buy his latest, **Frameshift**. You know it's good, you know he gets the techy bits right, and you know he's interesting and thought-provoking.

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So what should I tell you? As with the earlier *Terminal Experiment,* Sawyer is interested in the future of biological technologies. Here that means genetics, the Human Genome Project, the ethical dilemma of whether having the gene for a disease, but not the symptoms, should be regarded as having a "preexisting condition" for insurance purposes, the question of whether useful genetic material may be extracted from ancient (here, Neanderthal) bones, and more. To this he adds Ivan Demjanjuk, who was accused of being Ivan the Terrible, Ivan Marchenko, Ivan Grozny, the Butcher of Treblinka, stripped of his US citizenship, put on trial in Israel, and finally freed on grounds of mistaken identity. The real Marchenko is still at large, still a butcher, and someone has just attacked geneticist Pierre Tardivel with a knife. Tardivel's telepathic wife picks up the would-be killer's thought: Grozny ordered the hit.

Why? Tardivel has the gene for Huntington's chorea, a progressive brain deterioration that any insurance company can expect to cut into profits. His health insurance comes from Condor, a company that is quite concerned about restrictions on genetic discrimination and headed by a ruthless old man. And I dare not say any more for fear of giving far too much of the game away. Suffice it to say that there are red herrings and that the smelly fish permit Sawyer to consider indirectly both whether monsters may redeem themselves or are doomed to repeat their sins and to what extent the arrogance of science is comparable to that of Nazi war criminals.

The issues Sawyer is dealing with are not easy ones, but he builds an effective story from them. Much less to my taste is his distinctly fictional extension of genetics to say that all of human evolution, both past and future, is laid out in our genes, that indeed some almighty great designer wrote out the script. If he were right, surely some of the antipathy to modern genetics would disappear. But if his scheme is to work, humanity must have a limited span; indeed, from his scheme follows a way to calculate the Day of Judgment.

Perhaps that will be the centerpiece of his next novel.

Lisa Goldstein's latest, **Walking the Labyrinth**, is a genuine pleasure to read. A bit confusing at times, but deliberately so and never enough to spoil the pleasure.

Meet Molly Travers, a temp who was raised by her great-aunt Fentrice Allalie and knows very little about her family. Enter John Stow, private investigator, asking questions about what happened to Fentrice's sister Thorne, who disappeared many years ago, her brother Callan, and all the rest of a clan revealed by a 1935 newspaper article as accomplished stage magicians. Yet the reader already knows, thanks to the prologue, that the magic is more than mere prestidigitation. It is real, and really quite marvelous, and Molly has a background so enchanting that she very soon is deep into her own investigations.

Next stop: England, where the Al-

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lalie clan seems to have been linked to the mysterious Order of the Labyrinth, a manor house with a maze in the basement, old confessions of Powers and Deceptions and Manipulations, Victorian scandal, an old journal with missing pages, murder, jealousy, and finally a family's flight to America. Is the magic evil? Of course not; it's a talent. Yet it arouses envy and cupidity and thus leads to evil, and perhaps it is no surprise that the family chooses to conceal their talent, dressing truth as illusion.

The Labyrinth of the title is both the maze in the basement and the series of challenges we all face in our lives. As we defeat each one, we turn another corner in our personal Labyrinths, and the important question each time is, "What have you learned?"

In due time, Molly learns. She turns her corners, solves her problems, gets to know the family she has suddenly gained. And if she shares the family Power, that does not seem terribly relevant to her resolution.

If I were more specific, I would say too much. Leave it at this: The Allalies are people many of us would like to know, to have as friends. Their personalities and problems and lives feel very real to us. We put Goldstein's story down reluctantly, and we pray that she can do as well again.

Actually, she'll probably do better. She's been improving steadily for years.

A friend recently told me the joke about the programmer who, while walking along a forest path, came upon a frog. "Kiss me," said the frog. "And I'll turn into a beautiful princess and stay with you and do whatever you wish."

"Ha," said the programmer as he picked up the frog and stuffed it into a pocket. "I haven't got time for a girlfriend. But a talking frog is cool."

I've compressed the story a bit. As you know, such tales should be drawn out for effect. However, they should not generally be drawn out to book length. On the other hand, Nancy Springer is a unique treasure of modern fantasy, and when I hit something very like the above punch line on page 7 of **Fair Peril**, I did not get critical. Instead, I got the giggles.

Her heroine, Buffy, is fortyish, overweight, and bummed. After law school and three kids, her toad of a husband has dumped her for a trophy bimbo. Her youngest daughter, teen Emily, the last one at home, has gone off to live with Daddy and his Visa Gold. Buffy, so full of pride that she has refused alimony, is living in a hovel, working at the artificial food factory, and trying to develop a career as a storyteller. And when she finds that frog . . .

"Kiss me," he says. "I'm really Prince Adamus d'Aurca de la Pompe de la Trompe de l'Eau."

"Right," says Buffy. "You're a prop."

Enter Emily, who thinks this is pretty cool and pucker up, froggy.

Mama serves up a nifty body check and puts the kibosh on that notion real fast. But that doesn't stop the kid. A bit of smash and grab, and there's the prince, bare-ass naked and running for the mall hand in hand with Emily and the Visa Gold.

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With the aid of LeeVon, the librarian with a penchant for leather and body piercing, Muffy learns the spell for turning people into frogs, hits LeeVon by accident ("Kiss me," croaks LeeVon to a cop, "and I'll turn into a librarian!"), tries it on her ex but misspells the spell and turns him into a cloud of sewer gas instead, and finally twigs to the local mall as the realm of the fairies (especially the Food Court).

You get the idea. Good fun with a touch of risqué. Jolly and amusing, with lots more than that one initial giggle. Even a few outright guffaws. And there's a moral: everyone just wants someone to love them, but enslaving others for such a cause really won't do.

British SF writers have been famous for decades (ever since H.G. Wells and *The War of the Worlds*) for their penchant of visiting disasters—floods, freezes, Triffids, Martians—upon their fair land. Novel after novel, quite beyond the point of cliché, has been written about plucky bands of heroes venturing forth, making do against privation in the classic Robinson (Crusoe or Swiss Family) spirit, and finally saving the Empire. Or not, as the case may be; the point often seems to be thinking up new ways to trash the Victorian parlor.

Enter Joan Aiken and **The Cockatrice Boys**. This time the disaster is monsters—Basilisks and Gorgons, Cockatrices and Kelpies, Telepods and Bycorns, Hydras and Trolls, Sphynxes and Chichivaches, and deadliest of all, the Mirkindoles. Not to mention Snarks. They may have arrived in the guise of large, lumpy bags on an airline luggage carousel; alternatively, they may have something to do with the hole in the ozone. Whichever, soon much of the British populace has been digestively eliminated, the architecture lies in ruins, and the survivors, hunkered down in the Underground, have resolved to send out an expeditionary force to carry veggies to Manchester via rail. Communications are via a psychically amplified tea kettle.

Yes, it's just as cockeyed as it sounds. Even cockamamie and cockahoop. A bit of a send-up, amplified by illustrations that echo ancient bestiaries and histories. The forces of evil are here, and ancient wizardries, and a fair number of smiles for the readers.

Alas, the ending is a bit of a thud. Aiken never does settle the questions of where the monsters came from, how they got to England, who brought them, and why England alone had to suffer. Nor does she ever come back to the bags on that luggage carousel. The cover blurb calls the book "*Alice in Wonderland* meets *Salem's Lot*," but I think the nonsense less inspired than hasty and incompletely thought out, while the horror is not nearly up to the royal standard.

Fritz Leiber left us in 1992 at the age of 82. He also left behind a considerable body of work that had done a great deal to shape modern fantasy, and he well deserves an honored place in memory for that contribution. Yet he should also be remembered as a human being, a writer who was once

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learning the same craft that modern writers struggle to acquire; in fact as a writer who was himself subject to the shaping influences of others.

One of those influences was H.P. Lovecraft. In 1936, Leiber was even one of Lovecraft's many correspondents, and at that time he penned the manuscript of **The Dealings of Daniel Kesserich**. The story was never published (at least it is not mentioned in Tom Staicar's *Fritz Leiber* biography and bibliography [Ungar, 1983]), though David Hartwell tells us that it was revised for *Unknown* just before that magazine died, and the manuscript was lost in the 1950s.

And here it is in print at last, the tale of a recluse scientist, a doctor whose wife has just died of eating poisoned fruit in an orchard, a friend who comes to visit and finds mysterious pebbles appearing out of thin air, an exploding laboratory, townsfolk obsessed with the thought that they may have buried a woman alive, a raided grave, and a mysterious figure wrapped in bandages.

There are occasional intrusions of Lovecraftian eldritch menace—mentions of strange beings that walk in realms we cannot ordinarily touch—but they go nowhere. The tale is science fiction, not fantasy. The gimmick is a sort of time travel, not preternatural horror, and the bandages reveal an influence from another source—H.G. Wells.

Is it any good? To be frank, it's hard to picture it being published on its own merits. But it will definitely appeal to Leiber fans and scholars, for it casts light on an important stage in the development of a stellar imagination.

Herbert R. Lottman has earned plaudits for his biographies of Camus, Colette, and Petain. Now he turns his attentions to one of the founders of modern science fiction with **Jules Verne: An Exploratory Biography**. Relying hugely on Verne's many letters to parents, publisher, and friends, Lottman effectively portrays long struggles against paternal pressure to become an attorney, the attractions of writing for the ephemeral theaters of the Parisian boulevards, the need for money that led Verne into stockbroking, and the delicate digestive system that at one point had him writing to his mother about an "assload of enema" to which he had subjected himself. Verne thus becomes very human, a point worth remembering by everyone inclined to worship even if Lottman does lean rather heavily on outdated Freudianism to call Verne anal.

The jacket copy claims that Verne "has never been the subject of a modern biography until now." Granted that Lottman spends a fair amount of energy on correcting such early (1953) biographers as Marguerite Allotte de la Fuye (who, he says, had a tendency to create the documentation needed to support her tales), he does cite several recent French-language biographies (by grandson Jean Jules-Verne, 1973; Charles-Noel Martin, 1978; Simone Vierne, 1986; and Olivier Dumas, 1988). He does not mention the English-language biography by Peter Costello (Scribner's, 1978), which I happen to have on my own shelf.

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This book's value thus cannot lie in its being the only (modern) one of its kind. Rather, look to the personal touch, the bodily failings and psychological quirks, and then to the coverage of materials unpublished in Verne's lifetime (such as *Paris in the Twentieth Century,* whose long-forgotten manuscript was found in an antique safe).

Gregory S. Paul is an evolutionary biologist specializing in dinosaurs. Earl D. Cox is an artificial intelligence (AI) maven and consultant. Both men have been infected with the Hans Moravec bug, with **Beyond Humanity: CyberEvolution and Future Minds** as the result.

The thrust of the book is that computers are developing so rapidly that many people alive today will be able to download their minds into computers and then live forever. Those who refuse the opportunity will remain as they are, the scattered inhabitants of the planetary park the Earth will become, coddled by nanotechnology and AI guardians. The planets, stars, galaxies, and indeed the entire cosmos are the destined realm of cyber beings. Mere flesh and blood are just not capable of such things. Indeed, "Humanity is running out of steam. . . . We humans have had our run" (p. 429). The future is for our "mind children."

Paul and Cox qualify their projections with some care, but they are tremendously optimistic, in much the same vein as many *Analog* fact articles. They also buttress their argument with evolutionary theory, the basics of AI and nanotechnology, and a good deal of arm-waving speculation that holds the gists of many future SF stories. They make sense to someone who knows a bit about their topic; surely they scare the socks off those who don't, or those who are technophobic.

Unfortunately, their credibility suffers from two things. First, they have chosen a very breezy style, apparently in hope of appealing to those who know little about science and technology or science fiction. Second, though the text is well organized, it shows the lack of a competent line editor. The "Deep Blue" chess computer is at one point "Deep Purple." "Roboriots will make for great newscasts and bylines" makes no sense, since a byline is not a news story but the "by so-and-so" that follows the title on an article; it isn't affected by exciting news. There were more such slips as well, enough in fact to make a reader think the authors generally careless.

Still, this one should appeal to a great many *Analog* readers.

ANADEMS

When Borgo Press's Robert Reginald said in 1992 that he would like to see a book drawn from this column, I found the request quite flattering and hastened to oblige. The result was *Periodic Stars: An Overview of Recent Science Fiction,* constructed by selecting seventy writers whose works I had reviewed two or more times (with a couple of exceptions) between mid-1986 and 1992 (all the columns I then had on disk) and pre-

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senting the reviews of those works. When Reginald sent me the proofs, he wrote, "The material holds up very well, and will provide the largest body of worthwhile criticism on recent SF books available on the market. Many of these writers are covered in depth nowhere else."

Later he added, "What I find attractive . . . is that you're covering the newer books of well-known writers and the newer writers that haven't yet been covered in any critical monograph, and probably won't be for five or ten years . . . the critics and the fans should both find something worthwhile in [the book]."

Since I can't think why he would lie to me, I offer his remarks to you as the closest thing I have to a review. You, of course, already have a pretty good idea of what to expect.

The book is finally available, and my and Borgo's fond hope is that it will prove useful to scholars and libraries, not to mention writers who crave seeing themselves mentioned in a book instead of a magazine. The preface, introduction, and a list of the authors covered in the book are available at http://www.sff.net/people/teaston/.

And now Reginald says he wants more such books, one a year, say, until I run out of material. The next—later this year or early next—will be *Red Giants,* focusing on writers who have died or retired or reached what seems a late stage of their career during my tenure here. *T Tauri* will look at newer writers, at least in part. In due time, *Off the Main Sequence* will present what I've said about small and university press material (poetry, criticism, SF history, non-pro magazines, etc.), as well as science and digital publishing in the 1990s. And then, well, I'll need to find some new astronomy-motif titles unless I want to do *Periodic Stars II.* Suggestions are welcome. ■

It is in the nature of Apprentices not to comprehend the uses of the Armillary sphere.

—Barbara Ninde Ryfield

Let a smile be your umbrella if you want, but it's better to come in out of the rain.

—Kelvin Throop III

I've always felt that the faster you have to go, the better people you need.

—Stephen Burum, AS

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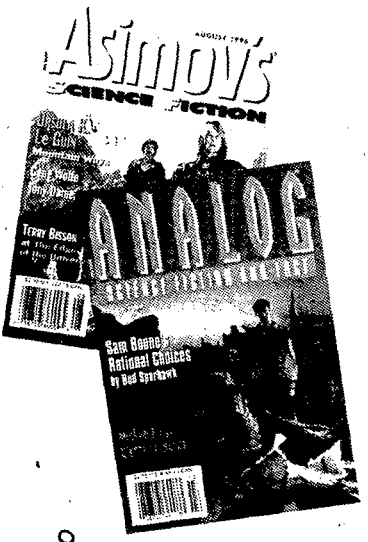

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BRASS TACKS

Dear Dr. Schmidt,

I've long enjoyed *Astounding*, and then *Analog*, with the Editorials at the top of my list.

In the September 1996 issue, you ask "how many 'real-life' situations can you think of in which information is accessed and outputted in any way resembling a multiple-choice test?"

Haven't you been to a supermarket recently?

Of course, one could argue that shopping is not a "real-life" situation, and I would agree completely.

A complicating factor in the study of knowledge processing is that "right brain" and "left brain" types do it differently. One of *Analog's* editorials many years ago pointed out that people who teach are very likely to see the world differently from those who "do." I wholeheartedly agree. Few of my teachers could understand why someone who found mathematics to be easy would have such difficulties with essays in the humanities.

MICHAEL R. TURNER
15713 SE 148th St.
Renton, WA 98059

Well, that's one, and I can think of others, such as answering opinion questionnaires. I never said the number was zero—but the fact remains that a great many "real-life" situations, such as driving a car to the supermarket, don't *work that way!*

Dear *Analog*:

I suppose it is appropriate to establish my credentials before launching into my dissertation: I have been an avid reader of science fiction literature for 45 years. I have attempted writing for the genre and never succeeded, but have never become less of a fan. My comments, following, are directed not only to you, but also to author Robert J. Sawyer. I have never been inspired to submit comments of this sort before.

Starplex is, without conditions, the most exciting, spellbinding, informative and entertaining work of science fiction I have ever had the pleasure to read! There is, simply, no comparison I can make to any of the thousands of short-short, short, serialized or novel-length works that have passed before my eyes.

I have learned more about astrophysics than I ever intended or wanted to know. I have been introduced to three "alien" species, and one homegrown species that man knows so little about as to be considered "alien." But, all are believable, and leave me yearning to know more about them

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and their relationships with one another and the human species.

For four months I have read and reread each of the episodes. Instead of being gratified when the final episode was concluded I was, as I have stated, yearning for more.

Congratulations on choosing to print *Starplex*. And sincerest thanks to author Robert J. Sawyer for creating this work. It should be, and probably will be, chosen to emulate science fiction literature for generations of up-and-coming authors.

Keep up the outstanding work of publishing interesting and entertaining literature found in the pages of *Analog*.

NORMAN E. CHURCHILL
14556 E. Tehachapi Blvd. #15
Tehachapi, CA 93561

Dear *Analog* and Ian:

In "The Coming of the Money Card: Boon or Bane?" *Analog*, October 1996, pages 64-71, Ian Randal Strock understates the power of privacy and anonymity that electronic transactions allow. It need not be true that electronic transactions must be recorded to work, if by "recorded" we mean that the payer, payee, and amount must be known.

In "Achieving Electronic Privacy," *Scientific American* 267, Number 2 (August 1992), pages 96-101, David Chaum describes the Digital Cash system, which is in use in Amsterdam and on the Internet. You can buy Digital Cash from Mark Twain Bank (http://www.marktwain.com/). Chaum's Digital Cash transactions support unconditional untraceability—even collusion by banks and merchants cannot identify the payer from information in a Digital Cash transaction.

A customer gets Digital Cash from a bank by asking the bank to sign a message that means, in essence, "This is a valid banknote." Actually, the message needs contain only a long random number and a check sum; it is the bank's signature that makes the note valuable. The bank has several public-private key pairs, one pair for each denomination of note. The bank digitally signs a message by encrypting it with the private key for the particular denomination. Because the resulting message can be decrypted with the bank's public key, anybody can verify a banknote is valid by performing that decryption and verifying the check sum is correct.

Such a signed note can be given to a merchant in payment. The merchant in turn deposits the note with their bank, and their bank redeems it from the issuing bank. Additional messages and signatures in Chaum's protocol provide receipts for each step, without compromising privacy.

If a bank signed a simple message to make a banknote, the bank could recognize that banknote when it was redeemed, and thus the bank could deduce where customers spent their notes. This is prevented by blinding each message before presenting it to the bank for signing. Blinding a message is achieved by multiplying a message with a random factor before giving it to the bank, and then dividing the bank's response by the blinding factor. The result is the same as if the

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bank had signed the original unblinded message, except the bank never sees that unblinded message.

The method by which this blinding is achieved is both surprising and simple. *(Editor's Note: We're sorry space doesn't permit showing the details, but see the* Scientific American *referenced above.)*

Chaum's article touches on other aspects of electronic transactions, such as catching attempts to spend money twice, security of stolen cards, proving other credentials such as a license to drive, et cetera. Money spent twice can be detected by comparing a note being spent with previous spent notes. That requires real-time verification. But Chaum mentions an additional system in which the payer is required to answer a random numeric query about each note when making a payment. In the *Scientific American* article, he does not describe how but says that one answer to a query does not compromise untraceability, while two answers create a digitally signed confession!

Security can be provided by a smart card that requires a PIN or other identification of its user before disbursing funds, but this identification need not be revealed to a merchant. By revealing the blinding factor (which a customer may store in a home computer or a backup smart card), a customer can ask a bank to stop or trace banknotes. This breaches confidentiality but makes it possible to fully recover unspent funds from a lost or stolen card.

In general, Chaum has demonstrated more capabilities than one might have expected in electronic transactions, and the issues in implementing these capabilities to retain the privacy of physical cash are political and economic in nature rather than technical.

ERIC POSTPISCHIL

edp@edp.org

The author replies ...

Dear Eric (and *Analog*),

I had most of that information when I wrote the article, though I think you may have been a bit clearer than the sources I was using.

My point was that, while it is entirely possible for a fair bank to maintain a customer's anonymity, it is equally possible for a bank that wants to breach that confidentiality to do so without the customer knowing.

If everyone was trustworthy and honest, there'd be no need for any of these security measures, but the fact that they are needed also points out the possibility of their being subverted.

IAN RANDAL STROCK

Dear *Analog*:

The most dangerous thing with the smart card money system is the ability of the government to shut your access off at will. Also, I am not a drug user or dealer, or a consumer or seller of any illegal materials, I am still however strongly against the government's ability to track my purchases. I resent your implication that only the individuals using black/grey market would not be in favor of government knowledge of individual habits. It is my considered opinion that no government

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may be trusted implicitly to respect the rights of the individuals in the area it governs. There is a very serious conflict of interest between a government (interested in the growth and exercise of power, which can only be done at the expense of individual liberty) and the individual (interested in living their own life by their own choices).

JASON VENNER
jason@idiom.com

The author replies ...

Dear Stan,

When speaking of a new technology, it is difficult to determine what will be *the* most dangerous aspect of it, though having a government cancel one's entire financial history is certainly a dangerous possibility.

I don't think I implied that "only the individuals using black/grey market would" oppose government knowledge of personal finances. My comment, on pages 67-69, was "Government regulation will encroach on many more aspects of private life because it can." Certainly not an endorsement on my part. While my "Privacy" sidebar on page 68 did say that people participating in black market economies would oppose such ready access of governments to private records, I did not say that it would only be those individuals. Indeed, I pictured them "lead[ing] the fight against governmental intrusion," much as the US founding fathers (or lead rebels, depending on your point of view) attacked an ever-encroaching government.

Please remember to make your opinion known before it's too late.

IAN RANDAL STROCK

Dear Dr. Schmidt,

I appreciated Mr. Strock's discussion of E-money, but am disappointed that he made no mention of "virtual money"; privately issued currency that circulates across the Internet.

While private currency is not new—it was the original variety—the varieties available in North America recently have been inconvenient, very localized, and fairly short-lived. I used some during my counter-culture days in Vancouver during the '70s.

Now, the possibility of easy, (possibly) secure, worldwide communication has led many to believe it is on the way back. While it will share most of the advantages and disadvantages of E-money, there will be differences. Virtual money can circulate in parallel with "official" dollars and perhaps will leave a fainter trail than US or Canadian dollars.

The June 1996 issue of *BYTE* magazine included several articles about systems like this.

Thank you (and your predecessors) for many years of pleasure.

GEORGE MCKINNEY
gmckinne@direct.ca

Dear Stan,

This is just a short note to tie up a couple of loose information ends and also to let you know that I spotted your "Thank You!" for sending you the Bishop essay mentioned in your latest editorial. Glad that it was useful.

Since I brought up the idea again

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about proposing Campbell for a commemorative stamp, I thought it might be a good idea to send you the additional information I got after calling the United States Postal Service at (1) (800) STAMPS-24 (782-677-24). Potential nominees may be recommended for a commemorative stamp by writing to the following address:

The United States Postal Service
Stamp Advisory Committee
Room 5301
475 L'Enfant Plaza, West Southwest
Washington, DC 20260-2420

No response will be made to suggestions, which may take up to three years to be implemented.

Know that you're busy, so no reply is necessary or expected. THANKS! for all of the continuing hard work you and everybody else continues to put into The Magazine.

MICHAEL D. TOMAN
604 Fremont Ave. #3
South Pasadena, CA 91030-2541

Dear Dr. Schmidt:

I am one of those people who would seldom send a letter but zip off e-mail if I discover that the company has an Internet address. Thank you for getting connected, since I have a complaint about one of your policies that has been bothering me for a long time.

Quite often you publish sequels to stories that you originally published months before (I call it serialus interruptus) and have a blurb at the end of the current story listing the originals and in which issue they can be found. The fact that the story in the current issue is a sequel should be the first thing the reader sees. No matter how hard the author tries to create a story that stands by itself, it always adds to the enjoyment to review the previous stories in the series before reading the current one. Sometimes I've started a story, realized I was reading a sequel, checked out the last page for the list of the previous issues (at the risk of glancing at the ending), gone into the back issues to review those stories, then finished the new one. I'm sure this is not how the author intended his work to be enjoyed. Please indicate at the beginning of a sequel where the previous stories can be found so we are not surprised that we are reading a sequel and do not run the risk of spoiling the ending of the current story.

How did the convention of putting the list of previous stories at the end of a sequel begin? Is there some obscure justification that makes sense in the publishing world? The only thing I can think of is that some newsstand browsers might be disinclined to purchase a magazine knowing it contains a sequel and the fact is hidden in the small type at the end of the story. How far off is that speculation? It seems to me the solution would be to provide a synopsis of the previous stories, like you do with any other serial.

PHILIP A. MOHR
flmr@aol.com

The notice of earlier stories is something we started adding at the ends of series stories because, as you say, some people like to go back and look at earlier ones. But nobody should have to, since we try hard to

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make each story stand on its own, and I'm afraid that putting the notice up front, and especially running a synopsis, would scare some readers off by making them think they do have to remember the earlier story to enjoy the new one. Also, a synopsis would eat up still more page space, a commodity already in short supply. ■

IN TIMES TO COME

Last November a versatile young man named Wolf Read made a most unusual *Analog* debut with both text and illustrations for the special feature article on "Epona," plus the cover and interior illustration for G. David Nordley's novella "Fugue on a Sunken Continent." Next month he broadens his scope still further by leading off our June issue with his own novella, "The Flowers That Bloom in the Spring"—and yes, he did the cover and illustration for this one, too. It's an innocuous-sounding title, you may think, but it's actually a tale of intense adventure involving some young people marooned uncomfortably far from the colony they were supposed to land at. The colony world is one that might well orbit our neighbor, Barnard's Star, with some most unusual characteristics. Imagine a place with a very short year and enough axial tilt to have strong seasonal variations. Imagine, in other words, a world where the seasons come so fast that you must literally race them for survival.

We'll also have new stories by Maya Kaathryn Bohnhoff and Laurence M. Janifer, while Jeffery D. Kooistra makes his first science fact appearance with "Paradigm Shifty Things." It's an intriguing survey of some of the more unorthodox results recently reported by scientists working in a variety of fields. Only time will tell whether any of them actually produce paradigm shifts, but Kooistra invites you to consider the evidence so far, check the original sources, and perhaps even try to confirm or refute them with your own experiments.

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UPCOMING EVENTS Anthony Lewis

8–11 May 1997
WORLD HORROR CONVENTION at Days Inn Fallsview, Niagara Falls, N.Y. Guests of Honor—Ramsey Campbell, Joe R. Lansdale, Poppy Z. Brite, Artist Guest of Honor—Rick Berry, TM—Edo van Belkom. Registration—$100 (to Niagara Falls SF Association). Info: World Horror Convention, Box 1072, Amherst, NY 14226. email: herphaus@pce.net

16–18 May 1997
OASIS 10 (Orlando area SF conference) at Harley Hotel, Orlando, Fla. Guest of Honor—*Stanley Schmidt*, editor of *Analog*, Artist Guest of Honor—Ron Walotsky, Fan Guest of Honor—Ray Herz. Registration—$22 until 15 March 1997, $25 at the door. Info: Oasis, Box 940992, Maitland, FL 32794-0992. (407) 263-5822

23–25 May 1997
CONQUEST 28 (Kansas City area SF conference) at Park Place Hotel, Kansas City, Mo. Guest of Honor—Larry Niven, Artist Guest of Honor—Alan Clark, Fan Guest of Honor—Bob Stoltman, TM—Andy Offutt. Info: ConQuest 28, Box 36212, Kansas City, MO 64172. email: sfreader@unicom.net

23–26 May 1997
DISCLAVE '97 (Washington area SF conference). Guest of Honor—Patricia Anthony, Artist Guest of Honor—Lisanne Lake, Fan Guest of Honor—Peggy Rae Pavlat. Registration—$30 until 30 April 1997, $40 at the door. Info: Disclave '97, 3064 White Birch Court, Fairfax, VA 22031. email: michaelnel@aol.com

28 Aug–1 Sep 1997
LONESTARCON 2 (55th World Science Fiction Convention) at San Antonio Convention Center, San Antonio, Texas. Guests of Honor—Algis Budrys and Michael Moorcock; Artist Guest of Honor—Don Maitz; Fan Guest of Honor—Roy Tackett, TM—Neal Barrett, Jr. Registration $135;supporting $25; children 3 to 12 $40, children 0 to 3 FREE (age as of 29 August 1997). This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info: LoneStarCon 2, Box 27277, Austin, TX 78755-2277. (512) 472-9944 (voice), (512) 435-7747 (fax), lsc2@io.com

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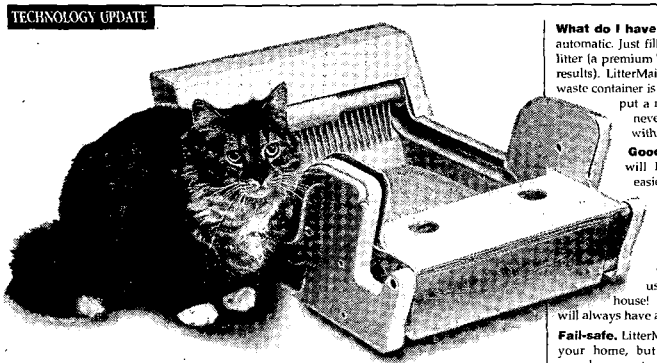

Never scoop cat litter again... Computer technology creates the only self-cleaning litter box!

You and your cat will love the way LitterMaid eliminates the hassle, mess and odor of the ordinary litter box.

by Shirley Liberles

Computer technology revolutionizes the litter box...

LitterMaid, a patented product from Waters Research Company, is a completely self-cleaning litter box operated by a microprocessor, but your cat uses it just like a normal litter box. Approximately 10 minutes after LitterMaid's "electric eye" senses that your cat has exited the litter box, it signals the start-up of the automatic sifting comb. ★ The comb sifts through the litter, scooping up any waste. ★★ The waste is deposited into a sealed, air-tight waste container and the comb returns to its original position, smoothing the litter. The system resets, ready to repeat its cycle the next time your cat uses the litter box. ★★★ When the waste container is full, you can either throw it away and put a new one in its place or empty it and reuse it for up to one year!

House cats. Large or small, affectionate or independent, young or old, long-haired or short, they all create the same dilemma for their owners—the litter box.

There are few things I can think of that are as foul as cleaning the litter box at my house. Even when I clean it daily, it's difficult to keep odor away. And this problem is multiplied because I have two cats! But because I love them, and that's virtually all the maintenance they require, I do it...because there's no other option.

Well, today there's a solution that cat owners across the country will be thrilled about. LitterMaid, manufactured by Waters Research, is destined to make ordinary litter boxes obsolete!

Automatic cleaning. LitterMaid is a computerized, completely self-cleaning litter box. Its operation is controlled by a microprocessor. An electric eye senses when the cat has exited the litter box, and minutes later, it signals the start-up of the automatic sifting comb. The comb sifts through the litter, scoops up any waste, and deposits it into a sealed, air-tight disposable waste container. The comb then returns to its original position, smoothing the litter. LitterMaid is now ready to begin another cycle as soon as necessary.

Revolutionary. LitterMaid may permanently change the face of the cat-product industry. Cat owners will never again have to endure the unsanitary and odor-filled chore of cleaning their cat's litter box. Plus, there will be no more embarrassing litter-box odor in your home, because the disposable waste container is sealed and totally air-tight!

What do I have to do? LitterMaid is fully automatic. Just fill the pan with *clumping* cat litter (a premium brand will provide the best results). LitterMaid does the rest! When the waste container is full, just throw it away and put a new one in its place. You'll never have unsanitary contact with cat waste again!

Good for your cat. Not only will LitterMaid make *your* life easier, it will make the litter box a nicer place for your cat. Most cats dislike using litter boxes that are dirty, and that can lead to them not going to the bathroom. Or worse, they may choose to use the bathroom around the house! With LitterMaid, your cat will always have a healthy, clean litter box.

Fail-safe. LitterMaid plugs into any outlet in your home, but it can also operate on eight "D" batteries. So even in the event of a power failure, LitterMaid will continue cleaning. It is equipped with an alarm that alerts you when the batteries are running low.

Put it anywhere. LitterMaid is only a couple inches longer and taller than conventional cat litter boxes. It should fit easily where your litter box is now—and you should put it there at first, until your cat gets used to it. But later, because LitterMaid is odorless and sanitary, you have the opportunity to place it virtually anywhere in your home—without any ordinary litter-box worries!

LitterMaid eliminates...

- *Embarrassing litter-box odors*
- *Having to endure the unsanitary and odor-filled chore of cleaning your cat's litter box*
- *Limiting the areas within your home in which you can place the litter box*
- *Worrying about how to clean the litter box if you go on vacation*
- *Having a cat who refuses to use the litter box because it's dirty*
- *Some risk of catching a disease from the cat's waste—this is especially important for pregnant women and people with immune deficiencies*

Try it risk-free. LitterMaid is backed by our exclusive risk-free home trial. Try it, and if you're not completely satisfied, return it within 90 days for a full refund, "No Questions Asked." It's also backed by a one-year manufacturer's limited warranty.

LitterMaid System . . . . . $199 $16 S&H
Waste container refills (4) . . . . . $11 $4 S&H

Please mention promotional code **1233-10564**.

For fastest service, call toll-free 24 hours a day

800-992-2966

To order by mail, send check or money order for the total amount including S&H (VA residents add 4.5% sales tax). To charge it, enclose your account number and exp. date.

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Midlothian, Virginia 23113

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TECHNOLOGY UPDATE

Fifteen years of microelectronic research makes conventional antennas a thing of the past!

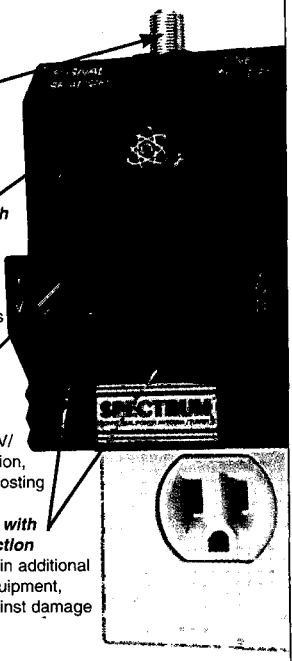
This little box uses your home's electrical wiring to give non-subscribers, cable subscribers and satellite users better TV reception on local broadcast networks!

Thanks to 15 years of microelectronics research, a new device has been developed that is so advanced, it actually makes conventional antennas a thing of the past. It's called the Spectrum Universal Antenna/Tuner.

Advanced technology. If you live in a rural area, you may have simply accepted the fact that your local TV reception is poor. This may be true even if you *don't* live in a rural area! Imagine watching TV and seeing a picture clearer than ever before. Plug your TV into the Spectrum Antenna and get ready for great reception—your TV will suddenly display a clearer, focused picture.

Uses your home's electrical wiring. The Spectrum Antenna plugs into a standard wall outlet. It turns the electrical wiring in your house or apartment into a multi-tunable TV antenna that will improve your TV's tuning capability.

Rural areas. Most TV signals in rural areas are weak, making them harder to fine tune. The "Gain Booster" is designed to increase the output level of the signal entering your TV, delivering a 10-fold greater signal. By using the Gain Booster, Spectrum's fine tuning controls will function better, giving it a stronger signal to tune. It also works in conjunction with your outdoor antenna!



Parallel 75 ohm resistance
For minimum loss of signal

Signal search control
For selecting multiple antenna configurations

Resonant fine tuner control
For dialing in crisp, clear TV/stereo reception, eliminates ghosting

Dual outlets with surge protection
For plugging in additional TV/stereo equipment, guarding against damage and surges

Try it risk-free. The Spectrum Antenna comes with our 90-day risk-free trial and a 90-day manufacturer's warranty. Try it yourself, and if you're not satisfied, return it for a "No Questions Asked" refund.

Spectrum Antenna ..... **$39** $4 S&H
Additional antennas ..... **$34** S&H free
Gain Booster ..... **$19** $2 S&H

Please mention promotional code **1495-10563.**

For fastest service, call toll-free 24 hours day

800-230-5023

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